POWERTECH (USA) INC.

Powertech (USA) Inc.
Dewey-Burdock Project
Underground Injection Control
Permit Application

April 2009

Prepared for

South Dakota
Department of Environment
& Natural Resources
PMB 2020
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Certification Requirements of Signatory

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine or imprisonment. This certification is submitted in accordance with South Dakota Administrative Rule 74:55:01:07.

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Date April 21, 2009

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List of Abbreviations and Acronyms

AEB	aquifer exemption boundary
AOR	area of review
ARSD	Administrative Rules of South Dakota
ASTM	American Society for Testing and Materials
BLM	U.S. Bureau of Land Management
CBA	Central Burdock Area
CFR	Code of Federal Regulations
cm/sec	centimetres per second
CPP	Central Processing Plant
DES	Draft Environmental Statement
EFN	Energy Fuels Nuclear
eH	measure of oxidation potential
EPA	U.S. Environmental Protection Agency
ft/day	feet per day
ft^2/day	square feet per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
GWPB	Ground Water Protection Branch
HPRCC	High Plains Regional Climate Center
HS&E	health, safety and environmental
ISL	In Situ Leach also referred to as in situ recovery
IX	ion exchange
M	million
Max WHP	maximum well head pressure
MCL	maximum contaminate level
MDL	minimum detection limits
mgd	million gallons per day
mg/kg	milligram per kilogram
mg/L	milligrams per liter
MIP	maximum injection pressure
MIT	mechanical integrity test
MVS	Mining Visualization System
MW	Monitor Well also referred to as Monitoring Well

NEPA	National Environmental Policy Act
NVLAP	National Voluntary Laboratory Accreditation Program
NRC	Nuclear Regulatory Commission
NWS	National Weather Service
OSHA	Occupational Safety and Health Administration
PA	Proposed Action
PAA	Proposed Action Area
pCi/L	picocuries per liter
pH	measure of acidity
PNL	Pacific Northwest Laboratory
PQL	Practical Quantitation Level
psi	pounds per square inch
psi/ft	pounds per square inch per foot
psig	pounds per square inch gauge
PV	pore volume
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCM	recording current meter
RCRA	Resource Conservation and Recovery Act
RO	reverse osmosis
SCFM	standard cubic feet per minute
SDCL	South Dakota Codified Laws
SD DENR	South Dakota Department of Environment and Natural Resources
SDGF&P	South Dakota Game Fish and Parks
SDSU	South Dakota State University
SDWA	Safe Drinking Water Act
SERP	Safety and Environmental Review Panel
SMCL	secondary drinking water standards
TDS	total dissolved solids
TRG	Target Restoration Goals
TSX	Toronto Stock Exchange
TVA	Tennessee Valley Authority
UCL	upper control limit
UIC	Underground Injection Control

USDW	underground source of drinking water
USGS	United States Geological Survey
WHP	well head pressure
wt%	weight percent

Glossary

Aquifer Exemption: The process by which an aquifer, or portion of an aquifer, that meets the criteria for an underground source of drinking water, for which protection under the Safe Drinking Water Act has been exempted under the criteria in 40 CFR 146.4. Injection of fluids through a Class I, II, or III injection well into any aquifer that meets the classification as a USDW requires a demonstration that the aquifer is not currently serving a drinking water system and is not expected to do so in the future.

Bleed: A small flow of water from a process flow stream for the purpose of affecting process pressure.

Brine Solution: A concentrated solution containing dissolved minerals (usually greater than 100,000 mg/l), especially chloride salts.

Central Processing Plant: The main processing facility that typically includes the ion exchange system, elution and precipitation circuits, settling and holding tanks, dewatering equipment, vacuum dryer and effluent control systems.

Confining Bed (layer): A geologic formation, group of formations, or a part of a formation of low permeability above and below an aquifer that confine groundwater to flow within the aquifer.

Elution: The process of extracting (or eluting) one material from another by washing with a solvent (eluant) to remove adsorbed material (such as uranium) from an adsorbent such as an ion exchange resin.

Excursion: Any unwanted and unauthorized movement of a recovery fluid detected and confirmed at the monitoring well ring.

Ion Exchange: A chemical process used to recover uranium from solution by the exchange of dissolved uranium ions between a lixiviant (leach solution) and a solid, either a mineral surface or, more commonly, a synthetic polymer resin

Injection Well: A well in which fluids are injected rather than produced, the primary objective typically being to maintain reservoir pressure. Two main types of injection are common: gas and

liquid. Liquid-injection wells are common offshore in the oil and gas industry, and in solution (in-situ) mining.

In Situ Leach: The in-place recovery of a mineral resource without removing overburden or ore. This method of mining is typically accomplished by installing a well and recovering the resource directly from the natural deposit by exposing it to the injection and recovery of the lixiviant that causes leaching, dissolution and recovery of the mineral. The term in situ leach is synonymous with the term in situ recovery (ISL) for the purpose of this document.

Lixiviant: A leachate solution pumped underground to recover the uranium from the ore body.

Monitor Well: A well used to obtain water quality samples or measure groundwater levels; also referred to as Monitoring Well

Ore Horizon: An interface indicative of the uppermost position of an ore body in a stratigraphic sequence.

Picocurie: One one-trillionth (1/1,000,000,000,000) of a Curie: a measure of radioactivity based on the observed decay rate of approximately one gram of radium. The Curie was named in honor of Pierre and Marie Curie, pioneers in the study of radiation.

Pore Volume (PV): Volume of water required to replace the water in the volume of aquifer that was mined.

Production Well: Also known as 'extraction well' for in situ recovery, usually located in the center of a 5 or 7 spot well pattern; used to pump the metal-laden solution to the surface for further treatment.

Radionuclide: An unstable form of a nuclide that decays or disintegrates spontaneously emitting radiation. Nuclide: a general term applicable to all atomic forms of an element. Nuclides are characterized by the number of protons and neutrons in the nucleus as well as by the amount of energy contained within the atom.

Safe Drinking Water Act (SDWA): The main federal law that ensures the quality of Americans' drinking water. The SDWA sets the framework for the UIC Program to control the

injection of fluids. EPA and states implement the UIC Program, which sets standards for safe injection practices and bans certain types of injection.

Satellite Plant: A remote plant consisting of an ion exchange system, pumps, reverse osmosis unit and transportation vehicles (tanker trucks) to transport loaded resins to the central processing plant.

Underground Source of Drinking Water (USDW): An aquifer or portion of an aquifer that supplies any public water system or that contains a sufficient quantity of ground water to supply a public water system, and currently supplies drinking water for human consumption, or that contains fewer than 10,000 mg/l total dissolved solids and is not an exempted aquifer.

Yellowcake: A mixture of uranium oxides that can vary in proportion and in color from yellow to orange to dark green (blackish) depending on the temperature at which the material was dried (level of hydration and impurities). Higher drying temperatures produce a darker, less soluble material. Yellowcake is commonly referred to as U3O8. This fine powder is packaged in drums and sent to a conversion plant that produces uranium hexafluoride (UF6) as the next step in the manufacture of nuclear fuel.

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1.0 Introduction

Powertech (USA) Inc. (Powertech) proposes to mine uranium at the Dewey-Burdock Site (hereafter the "Proposed Action Area") (PAA) using In Situ Leach (ISL) technology. This Underground Injection Control (UIC) permit application is being submitted to the South Dakota Department of Environment & Natural Resources (SD DENR). This UIC Class III application has been prepared in accordance with the requirements of the UIC Program promulgated under the Safe Drinking Water Act (SDWA) and South Dakota Administrative Rules §74:55:01 for the Proposed Dewey-Burdock Project (hereafter referred to as the "Proposed Action" (PA)).

The following statues and guidelines were utilized in development of this application:

Regulatory Guidance

- South Dakota Codified Laws Title 45, Chapter 6B and South Dakota Administrative Rules 74:55:01.
- South Dakota Administrative Rules 74:55:01 (Class III wells)
- 10 CFR Part 40 Appendix A as relevant and appropriate
- 40 CFR Part 144 Underground Injection Control Program
- 40 CFR Part 146 Underground Injection Control Program Criteria and Standards

Nuclear Regulatory Commission Documents

- 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/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).

Required Approvals and Submittals In Association with the In Situ Leach Mine Permit

A number of applications for licenses, permits and/or approvals are necessary for the various phases of the PA, which include evaluation, planning, construction, operation and reclamation. In addition to the UIC Class III permit application submitted to SD DENR under the Underground Injection Control Program(SDCL 34A-2 and Chapter 75:55), applications to other state and federal will be prepared and submitted in order to obtain authorizations under the following programs:

- In Situ Leach Permit submitted under Article 74:29 chapter §45:6B of SD DENR
- The state hazardous waste management program under SDCL chapter 34A-11
- The state solid waste permit program under SDCL chapter 34A-6, article 74:27, and chapters 74:54:01 and 74:54:02
- The state surface water quality program under SDCL chapter 34A-2 and article 74:52
- The state underground storage tank and aboveground storage tank program under SDCL chapter 34A-2 and article 74:56
- The state water rights permit program under SDCL title 46 and article 74:02
- The new source review, Prevention of Significant Deterioration, or Title V permit program under the Clean Air Act 42 U.S.C. § 7401 et seq. as amended through November 15, 1990, and under SDCL chapter 34A-1 and article 74:36, or minor source construction and operating air quality permit program under SDCL chapter 34A-1 and article 74:36
- The U.S. Army Corps of Engineers dredge and fill permit program under Section 404 of the Clean Water Act, as amended to January 1, 2008

- The U.S. Nuclear Regulatory Commission source material license program under 10 CFR Part 40 (January 1, 2007)
- Other relevant permitting programs, including other state and local permits or approvals

In addition to submitting this Class III UIC application to SD DENR, Powertech has submitted the Class III UIC Application to the U. S. Environmental Protection Agency (EPA) and the Source Materials License application to the Nuclear Regulatory Commission. At the State level, Powertech has submitted the required request for the department to determine whether or not the lands included in the proposed mining operation constitute special, exceptional, critical, or unique lands by submitting a notice of intent to operate to the Department. Powertech has received approval of two exploration permits submitted in 2007 and 2008 (Pending placement financial assurance for the latter).

1.1 Project Description

Uranium was first discovered in the Edgemont Uranium District in 1951, and recovery was accomplished for a number of years using conventional surface and underground mining methods. In the mid-1970s, the Tennessee Valley Authority (TVA) bought a major interest in the District and focused their main exploration target in the Dewey-Burdock area, where approximately 4,000 exploration holes were drilled. Silver King Mines, a TVA wholly owned subsidiary, was the operator for TVA, who continued drilling until the early 1980s when depressed uranium prices led to a halt in exploration activities. A draft environmental impact statement (DES) was prepared by TVA to address the impact of a proposed underground mine in the Dewey-Burdock area, but the National Environmental Policy Act (NEPA) process was never completed by TVA. TVA had relinquished all leases and claims and withdrew from uranium exploitation by the late 1980s. In 1994, Energy Fuels Nuclear (EFN) acquired the project but relinquished it in the late 1990s due to low uranium prices. In 2005, Powertech acquired the property.

The PA is located approximately 13 miles north-northwest of Edgemont, South Dakota and straddles the area between northern Fall River and southern Custer County line. The PAA encompasses approximately 10,580 acres (4,282 ha) 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. 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. Figure 1.1 shows the project location and permit boundary.

The Dewey-Burdock 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 two groundwater aquifers separated by the Fuson Shale Aquitard. The Lakota formation includes the Fuson shale and the Chilson sandstone units. The uranium occurs in the sandstones as classic roll front deposits with both oxidized and reduced zones located at both the Dewey and Burdock localities. Uranium minerals are deposited from down gradient flow of soluble oxidized uranium ions which encounter reducing chemical conditions within the aquifer causing precipitation of the uranium. At this interface of the oxidized groundwater and reduced groundwater, the uranium minerals precipitate, and coat the sand grains. Uranium mineralization can occur in several horizons within the aquifers resulting in multiple roll fronts. These roll fronts are typically "C" shaped in cross section, a few tens of feet wide and often thousands of feet long.

The estimated mineable resource, compliant with the National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101), within the PAA is 7.6 million pounds of U3O8 with an average grade of 0.21 percent. Subsequent to the publishing of the 43-101, Powertech has acquired properties with potential additional historical resources. The potential ISL mineable resources within the permit area were historically estimated by TVA at approximately 20 million pounds of U3O8. This resource is based on evaluation of approximately 4,000 exploration drill holes within the PAA. Evaluation of the lab and pumping hydrologic tests of the deposits indicate that the uranium is amenable to ISL mining techniques.

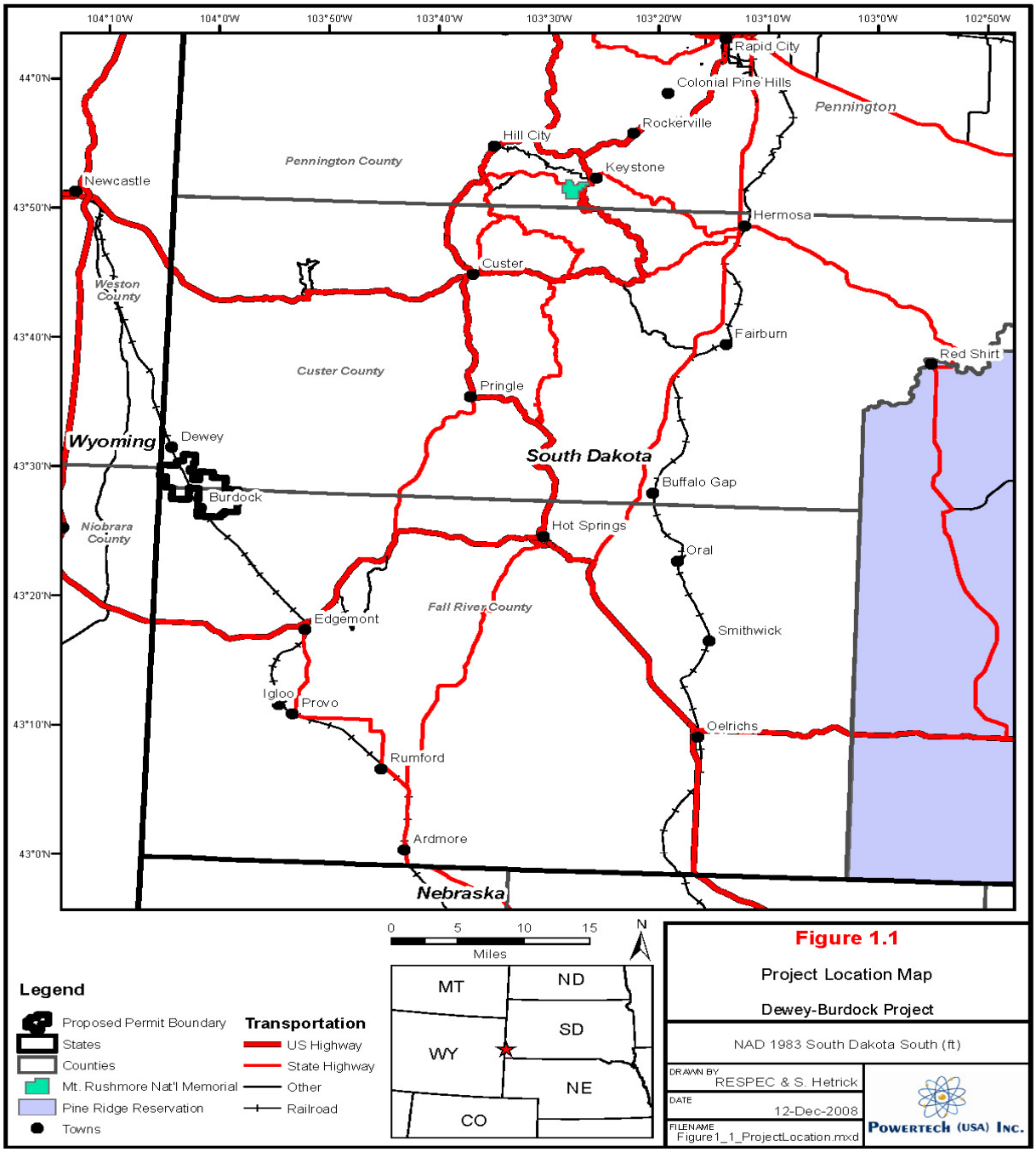

Figure 1.1: Project Location Map

The PA will consist of well fields, comprised of injection, production, and monitor wells, satellite ion exchange (IX) production facilities, and a central processing plant (CPP), consisting of an elution (resin stripping) system and precipitation and drying and packaging processes to produce a final uranium product (yellowcake). In addition, the Proposed Action will include, waste management facilities, office buildings and other structures or facilities to house work areas and equipment.

It is anticipated that the well fields at each site will operate at an estimated flow rate of between 1500 gallons per minute (gpm) to 2000 gpm. Uranium will be extracted and loaded onto ion exchange resin at both the Dewey and Burdock locations. Uranium extracted and loaded onto the ion exchange resin at the Dewey site will be transported to the CPP at the Burdock site for elution, precipitation, drying and packaging. The uranium extracted and loaded onto the ion exchange resin at the Burdock site will be transported to the central ion exchange stripping columns at the Burdock CPP for elution (stripping), precipitation, drying and packaging. The barren resin will be returned to the appropriate portion of the ion exchange circuit. Total production from both sites is expected to produce approximately 1,000,000 pounds of U3O8 per year, approximately evenly divided into 500,000 pounds per year at each processing site from the well fields located in each area.

1.2 Permitting Requirements

The EPA has primary enforcement authority for Class III wells in South Dakota. The SD DENR also regulates Class III wells. Therefore, this application is intended to fulfill both EPA and SD DENR regulatory requirements. Also, due to addition of the approximate 240 acres managed by the BLM, a plan of operation will be prepared and submitted for its review and approval.

This permit application has been prepared in accordance with the requirements of the Federal Safe Drinking Water Act (SDWA). The Safe Drinking Water Act was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supplies. This Act authorizes the EPA to set national health-based standards to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and groundwater wells which serve fewer than 25 individuals. The EPA, states and water districts work together to ensure protection against naturally-occurring and anthropogenic contaminants. The UIC Program found in 40 Code of Federal Regulations (CFR) Parts 144-147 is one such program designed to implement the SDWA by regulating underground injection practices to protect underground sources of drinking

water (USDWs). In addition, this application has met applicable rules promulgated by both the South Dakota Board of Minerals and Environment under the South Dakota Mined Land Reclamation Act (SDCL 45-6B), and the requirements from SD DENR Class III UIC regulations (74:55:01).

To fulfill these informational needs, the following attachments are included with this UIC permit application:

- A - Area of Review Methods
- B - Maps of Area and Area of Review
- C - Corrective Action Plan and Well Data
- D - Maps and Cross Section of USDWs
- F - Maps and Cross Sections of Geologic Structure of Area
- H - Operating Data
- I - Formation Testing Program
- J - Stimulation Program
- K - Injection Procedures
- M - Construction Details
- N - Changes in Injected Fluid
- O - Plans for Well Failures
- P - Monitoring Program
- Q - Plugging and Abandonment Plan
- R - Necessary Resources
- S - Aquifer Exemption
- U - Description of Business

1.3 Health, Safety, and Environmental Responsibilities

Powertech is committed to managing health, safety and environmental (HS&E) matters as an integral part of the PA. In particular, it is the company's policy to assure the HS&E integrity of activities and facilities associated with the PA at all times. Powertech will adhere to its principles of Compliance, Prevention, Communication and Continuous Improvement.

The company will implement programs to ensure strict compliance with all applicable laws and regulations.

Powertech's pre-operational and operational procedures are designed and implemented in such a way as to prevent releases to the atmosphere, land and water. The amount and toxicity of generated waste will be minimized and treated and disposed of properly.

Powertech's management has extensive technical and practical experience in permitting, operations and reclaiming ISL facilities. With the combined experience of Powertech working in conjunction with regulators, all necessary controls to assure that the highest HS&E standards are met, will be implemented.

Management systems and procedures specifically designed to prevent activities and/or conditions that pose a threat to human health, safety or the environment will be implemented. Risk will be minimized, and employees and the nearby communities will be protected by employing measures from the umbrella of safe technologies and operating procedures. Powertech will institute training and emergency preparedness in order to make the communities aware that Powertech has a commitment to open and transparent operations.

2.0 Attachment A - Area of Review Methods

The following attachment details the method used to determine the PA's Area of Review (AOR).

2.1 Introduction

The AOR is established to maximize the data to be described before an Aquifer Exemption is granted in order to prove the integrity of the injection zones and their relationship to surrounding USDWs. The AOR normally specified by the EPA is ¼ mile from the proposed permit boundary. Powertech chose an area of review more extensive than that required by the EPA due to the fact that the Nuclear Regulatory specifies a review area of 1.2 miles or (2.0 kilometers). The abundance of data from TVA on prior pumping tests performed for their planned DES yields excellent regional hydrologic information. This data in conjunction with other data available on regional water wells, Powertech believes that the integrity of the units within the Inyan Kara geologic group will be maintained thereby minimizing the opportunity for loss of fluids to any protected USDW either above or below the operating zone.

2.2 Area of Review Method

The EPA method used to determine the AOR for injection wells uses a minimum fixed radius of ¼ mile. The fixed radius AOR for this site specific area permit includes the project area (i.e., the well fields) plus a circumscribing area of no less than one mile. The following attachments summarize the activities planned by Powertech and are described utilizing the 1.2 mile external boundary chosen based upon the larger area of review required by the Nuclear Regulatory Commission (NRC).

- Chemistry of injected and formation fluids
  - Attachment H - Operating Data
  - Attachment N - Changes in Injected Fluid
  - Attachment S - Aquifer Exemption
- Hydrogeology
  - Attachment D - Maps and Cross Section of USDWs
  - Attachment F - Maps and Cross Sections of Geologic Structure of Area
  - Attachment I - Formation Testing Program

  - Attachment S - Aquifer Exemption
- Ground-water use and dependence
  - Attachment B - Maps of Area and Area of Review
  - Attachment S - Aquifer Exemption

The population and historic practices in the area are described in the following section.

2.2.1 Population and Land Use

Within a 6.2 mile (10 km) radius of the approximate center of the PAA, a determined number of 38 people reside (Knight Piésold, 2008). Three people reside within the AOR on a permanent basis and one dwelling within the AOR is used as a vacation home.

Table 2-1 lists the distance to the nearest occupied dwellings from the PAA according to 22.5-degree sectors centered on the 16 cardinal compass points in accordance with ARSD 74:55:01:26 (9). The nearest occupied dwelling is 0.9 miles to the west south-west of the PAA and is the only occupied dwelling within one mile of the PAA.

Table 2.1:Distance to Nearest Occupied Dwelling from Center of the Proposed Project

Sector	Distance from PAA 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

Land within the PAA is predominantly privately owned (97.5 percent) and the remaining 2.5 percent is managed by the BLM. Current land use within the PAA primarily consists of agriculture related to grazing, alfalfa hay production, hunting and historical mining. Also, historical mine sites exist along the eastern portion of the proposed permit area.

There is no commercial crop production within the permit area, although approximately 388.79 acres of land are irrigated for alfalfa periodically in Section 5, T 7S, R 1E and Sec. 32, T 6S, R. 1E along Beaver Creek. The majority of agricultural production is related to grazing. Most of the land serves as grazing land for feed cattle, as well as a few horses.

Between 1951 and 1964, approximately 1,500,025 pounds (680,400 kilograms) of U3O8 was produced from underground and open pit mines in the Edgemont Uranium District (TVA, 1979). The Darrow, Spencer Richardson and Triangle uranium mine pits are located within the PAA

boundary. The Freezeout and Lucky Strike uranium mine pits are located just northeast of the PAA (Table 2.2).

Table 2.2: Mines within One Mile of the Proposed Dewey-Burdock Boundary

Name	Township	Range	Section	Qrt Section	SD State Plane 1983		Area (acres)
					East (ft)	North (ft)	
Triangle	6	1	34	NE	1001770.6	442659.63	69
Spencer Richardson[1]	6	1	35	SE	1005548.3	440243.66	28
Darrow	7	1	1 and 2	NA	1007656.8	435455.66	217
Freezeout	6	1	36	SW	1009842.1	439075.66	ND
Lucky Strike	6	1	36	NE	1011383.1	442490.03	ND

Notes:
ND = Not Determined
NA = Not Applicable
[1]Partially reclaimed

Recreational use within the PAA is limited primarily to large game hunting. Within the project area, 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 (SDGF&P) lease around 3,069 acres annually of privately owned land and currently designate this acreage as walk-in hunting areas. GCC Dacotah, Inc owns 2,380 acres, designated as a SDGF&P Special Management unit that currently allows hunting. Fishing and other water-based recreational activities on streams within the project vicinity are limited due to low flows and turbid water conditions. Upon receipt of applicable permits and prior to commencing project activities, all hunting will be prohibited within the Permit Boundary.

Dewey Road, a gravel road leading north from Edgemont, serves as the main access to the permit area. Other, mostly unimproved gravel roads crisscross the project at irregular intervals. A major rail line, Burlington Northern Santa Fe Railroad, lies across the center of the permit area. This railroad is a primary transportation corridor for Powder River Basin coal. Powertech is aware of Dakota Minnesota & Eastern rail plans in the area.

2.2.2 Climatic Data

The proposed project is located in an area in south-western South Dakota that can be characterized as a semiarid or steppe climate. It lies adjacent to the south-western 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. 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 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 and shown in Appendix A) 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 Proposed Action 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). Refer to Appendix A for details concerning regional and site specific climatic data.

2.3 Summary

A maximum distance ¼ miles from the proposed well fields is deemed sufficient to encompass all potential UIC activities. Powertech's review area was set outside the AOR to 1.2 miles or (2.0 kilometers) beyond the proposed permit boundary. This extended area of review not only

satisfies EPA, SD DENR and NRC criteria, it will also serve to minimize the stakeholder's concerns about controls that will be utilized in the ISL operations.

3.0 Attachment B - Maps of Area and Area of Review

Attachment B contains maps of the area and AOR. The information provided in each map is described below.

3.1 Area of Review

Plate 3.1 is a topographic map covers the entire AOR, and describes the following information:

- The proposed permit boundary
- AOR boundary (discussed in Attachment A)
- The "project area" (i.e., the proposed well field locations)
- Proposed Facilities
- All drinking water wells
- All producing wells
- Surface bodies of water
- Mines (surface and subsurface)
- Residences
- Roads
- Faults

Drinking water wells and other producing wells are color coded to designate which aquifer the wells are completed into and the depth of completion. Powertech is aware of four drinking water wells within the AOR, one of which, the Daniel's, is located within the proposed aquifer exemption boundary and completed within the mineralized aquifer. Powertech subsequently replaced the Daniel's well with a well completed in a deeper non-mineralized aquifer, the Unkpapa. The original well was not plugged or abandoned as the owner may utilize this water for cattle.

All available information concerning dwellings, utilities, and easements within the PAA and adjacent lands in relation to all proposed affected lands and proposed activities associated with the in situ leach operation is contained in Figure 3.1. A map and table of all adjudicated groundwater and surface water rights are presented in Appendix B. There are no groundwater

water rights within the permit boundary and only two water rights within 2 miles of the permit boundary. The majority of water rights in this area are surface water rights with 5 surface water rights existing within the permit boundary and an additional 139 within 2 kilometers of the PAA. The majority of the surface water rights are located along Beaver Creek within Wyoming.

No injection wells, intake structures, discharge structures, hazardous waste treatment, storage, or disposal facilities have been identified in the AOR or within one mile of the proposed permit boundary. Springs identified on USGS topographical maps outside the AOR but within one mile of the project were not found during field investigations. This suggests that springs are no longer present and would not be considered flowing wells as illustrated in Figure 17.1. No quarries are located within one mile of the proposed permit boundary; however, a quarry is located on the GCC Dacotah property to the north of the PAA boundary.

Figure 17.1 identifies the following features typically found on a site plan map:

- Proposed permit boundary
- AOR boundary
- Initial well field areas circumscribed by monitoring well ring
- Ore body outlines beyond the initial areas
- Aquifer exemption boundary (AEB)

The distribution manifold including header house and system monitoring points, as well as monitoring wells are described in Attachment H - Operating Data.

3.2 Abandoned Drill Holes

Over 5,800 exploration drill holes are known to have been drilled and abandoned within the one mile perimeter around the PAA prior to acquisition of the property by Powertech in 2005. As of August 2008, Powertech has drilled, plugged and abandoned 94 additional verification drill holes within the AOR. Figure 3.2 illustrates the locations of historic drill holes drilled by others and Powertech drill holes.

Additional information pertaining to drill holes and wells within the AOR is provided in the following attachment, specifically, Attachment C - Corrective Action Plan and Well Data.

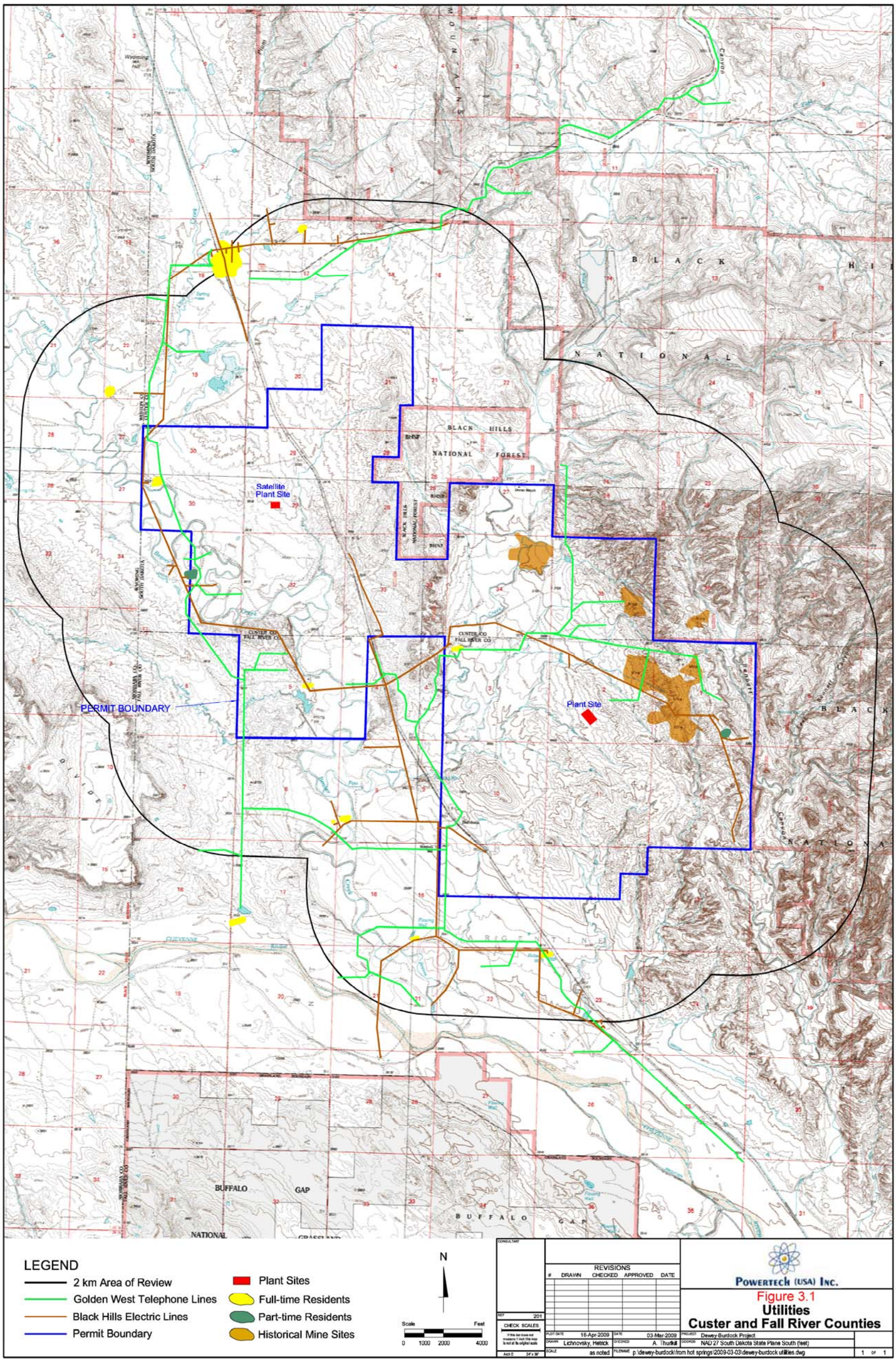

Figure 3.1: Utilities Custer and Fall River Counties

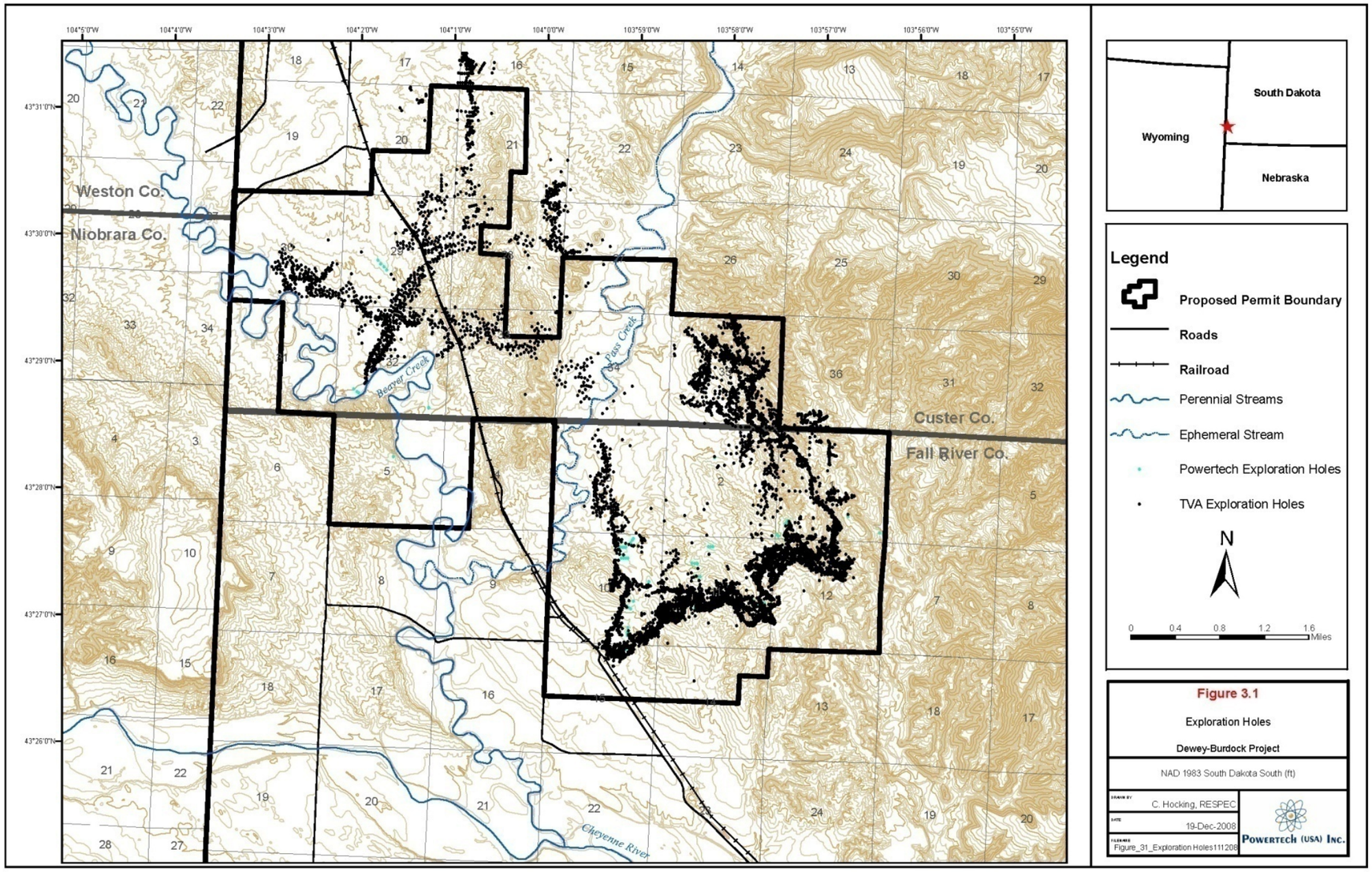

Figure 3.2: Exploration Holes

4.0 Attachment C - Corrective Action Plan and Well Data

Coverage of corrective action will include known wells designated by Powertech hydrologists having a degree of potential affect upon mining operations within the project area. Powertech Class III wells that penetrate the injection zone within the proposed permit area and one – quarter mile outside the property boundary that are determined by Powertech hydrologists to be affected by increased pressures due to a mechanical integrity test (MIT) and pumping tests, will be properly sealed, completed, or abandoned. If a well lacks mechanical integrity or is in a condition that precludes the use of that well for injection, corrective action to prevent the movement of fluids into USDWs will be implemented in accordance with 40 CFR Part 144.55. There are currently no existing injection wells in South Dakota; however, corrective action for new wells is covered under ARSD 74:55:0. Powertech's Corrective Action Plan covers methods concerning existing and new injection wells that comply with both EPA and South Dakota rules. The following attachment details the steps or modifications necessary to prevent movement of fluid into unauthorized zones. A corrective action plan to prevent the migration of fluid into any USDW from PAA wells is detailed in Attachment O - Plans for Well Failure.

4.1 Well Data

Appendix C contains all known available well data from public records or from the company's investigation with local land owners.

- Well type
- Ownership information
- Construction data
- Location (latitude/longitude)
- Total depth
- Completion formation
- Date drilled
- Condition of cementing
- Source of completion or plugging and abandonment information
- Additional information related to any tendency or characteristic that many cause or prevent a breach in the confining zone

Figure 4.1 illustrates wells that have been plugged and abandoned within 1 mile of the proposed permit boundary.

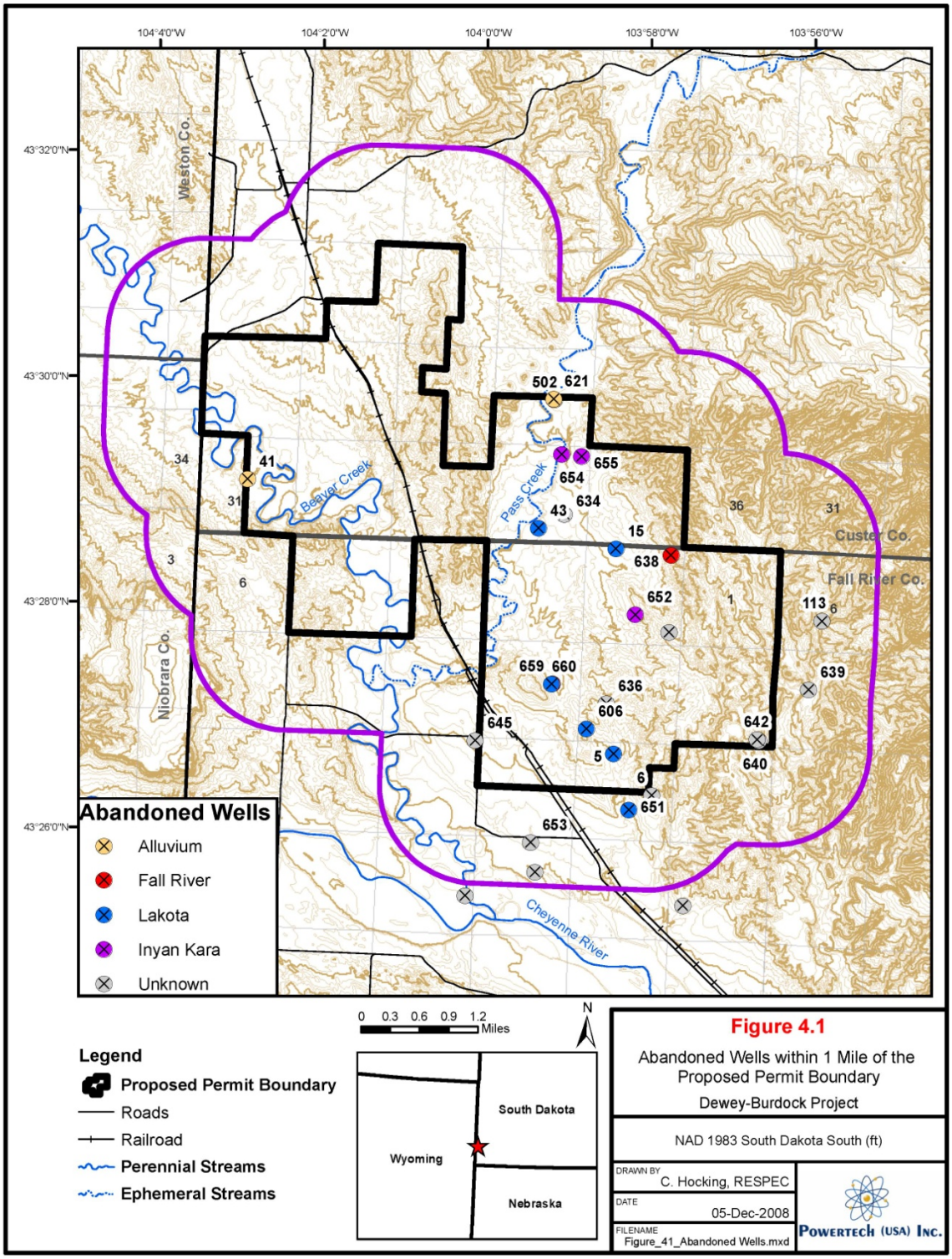

Figure 4.1: Abandoned Wells within 1 Mile of the Proposed Permit Boundary

Appendix D summarizes the available information for historic drill holes within the AOR. Information obtained by Powertech suggests that historic drill holes within the AOR were abandoned using either abandonment bentonite, drilling mud or a combination of bentonite and drilling mud. In addition, it is well documented that most abandoned drill holes that are completed with drilling muds, swell shut in a few days due to natural clay swelling and formation weight. However, if improperly abandoned drill holes are detected during well field installation (e.g., communication is detected during a pump test), Powertech will plug the drill holes in accordance with the procedures outlined in Attachment Q - Plugging and Abandonment Plan.

The following Table 4.1 documents the plugging and abandonment of Powertech's exploration drill holes. The drill hole abandonment procedures follow the South Dakota plugging standards (ARSD 74:11:08).

Table 4.1: Powertech Drill Holes Plugged and Abandoned within the One Mile Perimeter around the PAA

Drill Hole Number	SD State Plane 1983 Easting Surveyor	SD State Plane 1983 Northing Surveyor	Section-Township-Range	Starting Date Drilled	Date Logged	Total Depth Driller	Total Depth Logger
DB 07-1-1	1039398.5	433963.91	1-7S-1E	7/8/2007	7/8/2007	430	424
DB 07-1-2	1039352.5	433841.27	1-7S-1E	7/10/2007	7/10/2007	470	467
DB 07-1-3	1039274	433796	1-7S-1E	7/11/2007	7/11/2007	450	454
DB 07-1-4	1038963.9	433190.41	1-7S-1E	7/16/2007	7/16/2007	460	444
DB 07-1-5	1038849	433279.54	1-7S-1E	7/18/2007	7/18/2007	380	379
DB 08-1-6	1043742	433344.21	1-7S-1E	3/24/2008	3/24/2008	250	244
DB 08-1-7	1042271.3	434136.81	1-7S-1E	4/14/2008	4/18/2008	575	575
DB 08-2-1	1035918.6	436952.4	2-7S-1E	3/21/2008	3/21/2008	247	246
DB 07-3-1	1031018	434086	3-7S-1E	11/28/2007	11/29/2007	660	642
DB 07-3-2	1031080	434187	3-7S-1E	11/30/2007	12/3/2007	680	659
DB 07-3-3	1031113	434264	3-7S-1E	12/10/2007	12/12/2007	635	632
DB 07-3-4	1031478	435151	3 7S-1E	12/16/2007	12/19/2007	650	649
DB 08-3-5	1031714.7	434958.77	3-7S-1E	1/7/2008	1/11/2008	670	666
DB 08-3-6	1031701.3	434957.77	3-7S-1E	4/2/2008	4/4/2008	620	615
DB 08-3-7	1031629.1	435017.7	3-7S-1E	4/4/2008	4/5/2008	610	552
DB 08-3-8	1031577.2	435089.64	3-7S-1E	4/6/2008	4/7/2008	610	609
DB 08-5-1	1020684.4	437010.11	5-7S-1E	4/16/2008	4/1/2008	990	990
DB 07-10-1	1031778.4	428440.23	10-7S-1E	5/9/2007	5/9/2007	677	570
DB 07-10-2	1031772.2	428533.73	10-7S-1E	5/11/2007	5/11/2007	560	556
DB 07-10-3	1031777.3	428616.61	10-7S-1E	5/12/2007	5/12/2007	570	565
DB 07-10-4	1032055.1	430989.9	10-7S-1E	5/26/2007	6/6/2007	624	624
DB 07-10-5	1031788.4	428852.24	10-7S-1E	5/13/2007	5/14/2007	580	579
DB 07-10-6	1031964	430913	10-7S-1E	5/15/2007	5/16/2007	610	607
DB 07-10-7	1031880.4	430912.46	10-7S-1E	5/21/2007	5/24/2007	604	615
DB 07-10-8	1031804.2	430907.7	10-7S-1E	5/24/2007	6/7/2007	620	499
DB 07-10-9	1032767	430777.24	10-7S-1E	5/14/2005	5/15/2007	600	600
DB 07-10-10	1032775.7	430908.59	10-7S-1E	5/13/2007	5/14/2007	620	617
DB 07-10-11	1032783.5	431036.95	10-7S-1E	5/12/2007	5/12/2007	552	552
DB 07-10-12	1031491.3	432153.73	10-7S-1E	6/7/2007	6/9/2007	600	595
DB 07-10-13	1031589.9	432147.37	10-7S-1E	6/11/2007	6/12/2007	620	617
DB 07-10-14	1031679.3	432148.5	10-7S-1E	6/9/2007	6/10/2007	620	
DB 07-10-15	1031786.1	432141.79	10-7S-1E	6/18/2007	6/19/2007	630	620
DB 07-10-17	1031437.9	432686.08	10-7S-1E	6/19/2007	6/20/2007	660	663
DB 07-10-19	1031531.7	432687.02	10-7S-1E	6/24/2007	6/25/2007	670	630
DB 07-10-20	1031583.8	432679.66	10-7S-1E	6/22/2007	6/23/2007	660	628
DB 07-10-21	1031633.3	432680.53	10-7S-1E	7/6/2007	7/7/2007	670	624
DB 07-10-22	1031683.4	432678.33	10-7S-1E	6/21/2007	6/22/2007	660	654
DB 07-10-23	1031935.5	429714.24	10-7S-1E	6/5/2007	6/6/2007	604	559
DB 07-10-24	1031836	429768.27	10-7S-1E	6/7/2007	6/8/2007	630	630
DB 07-10-25	1031759.8	429814.18	10-7S-1E	6/9/2007	6/10/2007	630	623
DB 07-10-26	1031665.4	429865.96	10-7S-1E	6/10/2007	6/11/2007	630	616
DB 07-10-27	1032769.1	430843.01	10-7S-1E	5/28/2007	5/30/2007	620	619
DB 07-10-28	1032051.7	430071.93	10-7S-1E	6/12/2007	6/13/2007	620	621
DB 07-10-40	1031920.5	432883.75	10-7S-1E	6/25/2007	6/26/2007	670	665
DB 07-10-41	1031966	432960.8	10-7S-1E	10/6/2007	10/7/2007	675	674
DB 07-10-42	1032004.3	433026	10-7S-1E	7/10/2007	7/11/2007	675	673
DB 07-10-43	1032044.2	433094.17	10-7S-1E	7/5/2007	7/6/2007	675	654
DB 07-11-1	1035258	431256.77	11-7S-1E	5/24/2007	5/25/2007	593	585
DB 07-11-2	1035138.1	431266.07	11-7S-1E	5/23/2007	5/24/2007	592	585
DB 07-11-3	1035023.4	431277.18	11-7S-1E	5/21/2007	5/22/2007	590	590
DB 07-11-4C	1035074.6	429984.9	11-7S-1E	6/18/2007	6/22/2007	575	557
DB 07-11-5	1034857.3	431899.58	11-7S-1E	5/28/2007	5/29/2007	620	615
DB 07-11-6	1034981.9	431895.13	11-7S-1E	5/26/2007	5/27/2007	634	624
DB 07-11-7	1035116.8	431891.25	11-7S-1E	5/25/2007	5/26/2007	600	592
DB 07-11-8	1035612.3	432704.57	11-7S-1E	5/29/2007	5/30/2007	650	628
DB 07-11-9	1035718.2	432695.88	11-7S-1E	6/4/2007	6/5/2007	630	592
DB 07-11-10	1035836.1	432692.74	11-7S-1E	6/6/2007	6/7/2007	610	607
DB 07-11-11C	1035077.2	429975.67	11-7S-1E	10/8/2007	10/10/2007	450	449
DB 07-11-12	1037708.8	430209.15	11-7S-1E	10/16/2007	10/17/2007	445	446
DB 07-11-13	1037715.7	430384.16	11-7S-1E	10/17/2007	10/18/2007	455	456
DB 07-11-14C	1035190	429752.86	11-7S-1E	10/30/2007	11/2/2007	458	452
DB 07-11-15	1034969.4	429757.45	11-7S-1E	11/3/2007	11/4/2007	495	490
DB 07-11-16C P&A	1035126.4	429971.49	11-7S-1E	11/12/2007	11/17/2007	710	701
DB 08-11-17	1035038.3	429982.44	11-7S-1E	3/25/2008	3/25/2008	270	268

Table 4.1: Powertech Drill Holes Plugged and Abandoned within the One Mile Perimeter around the PAA

Drill Hole Number	SD State Plane 1983 Easting Surveyor	SD State Plane 1983 Northing Surveyor	Section-Township-Range	Starting Date Drilled	Date Logged	Total Depth Driller	Total Depth Logger
DB 08-11-18	1035112.8	429979.18	11-7S-1E	4/1/2008	4/1/2008	660	659
DB 08-11-19	1035074	430021.41	11-7S-1E	4/4/2008	4/4/2008	370	368
DB 07-11-28	1037994.9	429879.47	11-7S-1E	6/11/2007	6/12/2007	425	414
DB 07-11-29	1038096.3	429919.63	11-7S-1E	6/10/2007	6/11/2007	420	418
DB 07-11-30	1038188.7	429955.12	11-7S-1E	6/9/2007	6/10/2007	630	422
DB 07-11-31	1038288.5	429994.33	11-7S-1E	6/7/2007	6/8/2007	630	630
DB 07-12-3	1041096.2	431846.98	12-7S-1E	10/23/2007	10/23/2007	355	355
DB 07-12-4	1040927.1	431845.23	12-7S-1E	7/18/2007	7/19/2007	350	353
DB 07-12-6	1038809.4	429792.42	12-7S-1E	10/20/2007	10/20/2007	420	418
DB 07-15-1	1031705.2	427799.95	15-7S-1E	5/11/2007	5/11/2007	584	548
DB 08-15-2	1028498.5	427242.9	15-7S-1E	3/10/2008	3/10/2008	625	625
DB 08-15-3	1028535.8	427151.06	15-7S-1E	3/18/2008	3/19/2008	450	447
DB 07-29-1C	1021308.6	445301.83	29-6S-1E	10/1/2007	10/7/2007	876	875
DB 07-29-2	1020357.2	445972.46	29-6S-1E	9/19/2007	9/21/2007	856	715
DB 07-29-3	1019883.3	446512.42	29-6S-1E	9/17/2007	9/19/2007	816	822
DB 07-29-4	1020076.2	446255.55	29-6S-1E	9/21/2007	9/23/2007	875	874
DB 07-29-5	1019975	446385.72	29-6S-1E	9/24/2007	9/25/2007	875	876
DB 07-29-6	1019928.4	446448.6	29-6S-1E	9/26/2007	10/2/2007	875	880
DB 07-29-7	1020211.5	446113.73	29-6S-1E	11/18/2007	11/19/2007	660	667
DB 07-32-1C	1020381.8	443723.61	32-6S-1E	6/23/2007	6/27/2007	800	805
DB 07-32-2C	1020370	443091.77	32-6S-1E	7/5/2007	7/8/2007	815	805
DB 07-32-3C	1020327.3	443724.01	32-6S-1E	11/16/2007	11/27/2007	630	601
DB 07-32-4C	1020689.2	443419.09	32-6S-1E	11/28/2007	12/4/2007	630	638
DB 07-32-5	1020080.6	443734.99	32-6S-1E	11/14/2007	11/17/2007	630	634
DB 07-32-6	1018784.3	440243.74	32-6S-1E	12/11/2007	12/14/2007	690	683
DB 08-32-7	1018943.7	440127.19	32-6S-1E	1/9/2008	1/11/2008	630	610
DB 08-32-8	1019020.6	440063.98	32-6S-1E	1/12/2008	1/15/2008	630	632
DB 08-32-9C	1020363.4	443708.22	32-6S-1E	1/12/2008	1/15/2008	630	633
DB 08-32-10	1020314.7	443790.44	32-6S-1E	1/25/2008	1/26/2008	825	825
DB 08-32-11	1020325.7	443671.39	32-6S-1E	2/4/2008	2/8/2008	1030	1030
DB 08-32-12	1022349	439356.55	32-6S-1E	2/23/2008	2/26/2008	845	842
DB 08-32-13	1022382.9	439321.6	32-6S-1E	3/4/2008	3/7/2008	570	570

Baseline Wells
Pump Test Wells
Water Wells
Handheld GPS

4.2 Wells Requiring Corrective Action

For decades, it has been common practice in the area to allow free-flowing wells to continually discharge, largely to prevent freezing during winter. The attached map shows artesian wells within the AOR that will be monitored to determine if corrective action will be needed (Figure 4.2). This determination will be made during well field design phase.

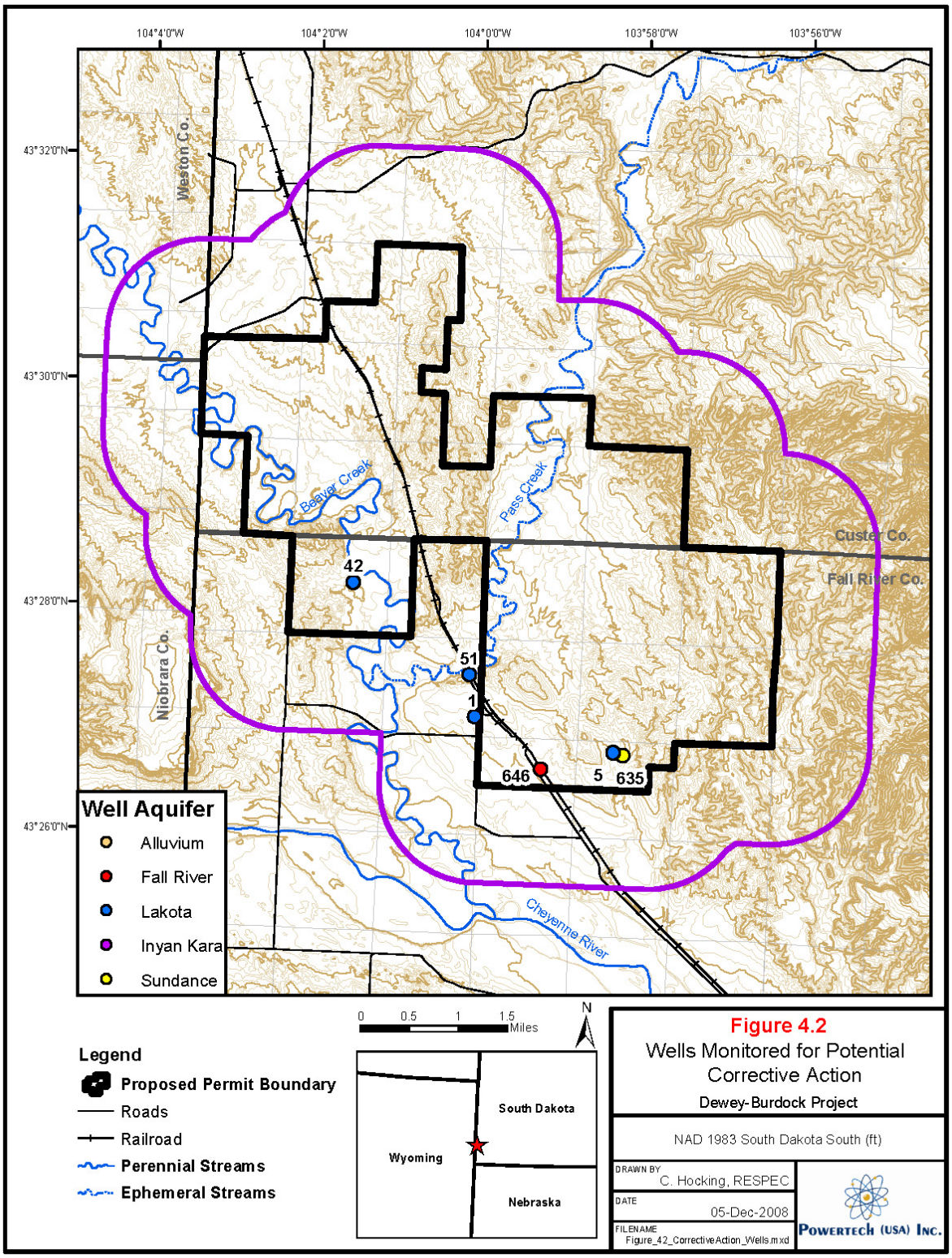

Figure 4.2 Wells Monitored for Potential Corrective Action

4.3 Corrective Action Plan

Corrective action will be taken, on a case by case basis, if any additional wells are identified within the monitoring well ring that have not been properly sealed, completed or abandoned and have potential to allow fluids to migrate into a USDW. Wells requiring corrective action will be identified and their locations will be provided to the EPA. Efforts will be made to re-enter and repair these wells. If repair is unsuccessful, the wells will be plugged and abandoned following the procedures outlined in Attachment Q -Plugging and Abandonment Plan wells to prevent the migration of fluids into a USDW.

4.4 Operational Pumping Tests

Prior to the start-up of a well field, pumping tests will be conducted to demonstrate that communication between the production zone and the underlying or overlying aquifers is not taking place. In some cases there may not be an underlying aquifer as the Morrison formation contains approximately one hundred feet of shale and therefore is a confining unit. If pumping test results indicate that leakage between aquifers has occurred, the leakage will be addressed according to accepted standards by modification of operational practices as warranted.

5.0 Attachment D - Maps and Cross Section of USDWs

The following attachment includes regional scale maps and cross sections that show the geologic structure and overlying and underlying USDWs relevant to the PAA. Supporting details are provided in the following sections.

5.1 Regional Hydrogeology

Five major aquifers are utilized as groundwater resources in the Black Hills. These main aquifers are the Precambrian fractured granite and metamorphics, Deadwood sedimentary rocks, Madison limestone, Minnelusa sedimentary and evaporative units, and the Inyan Kara Group of sandstones. The groundwater hydrology is influenced by its location relative to the Black Hills uplift 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 5.1 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.

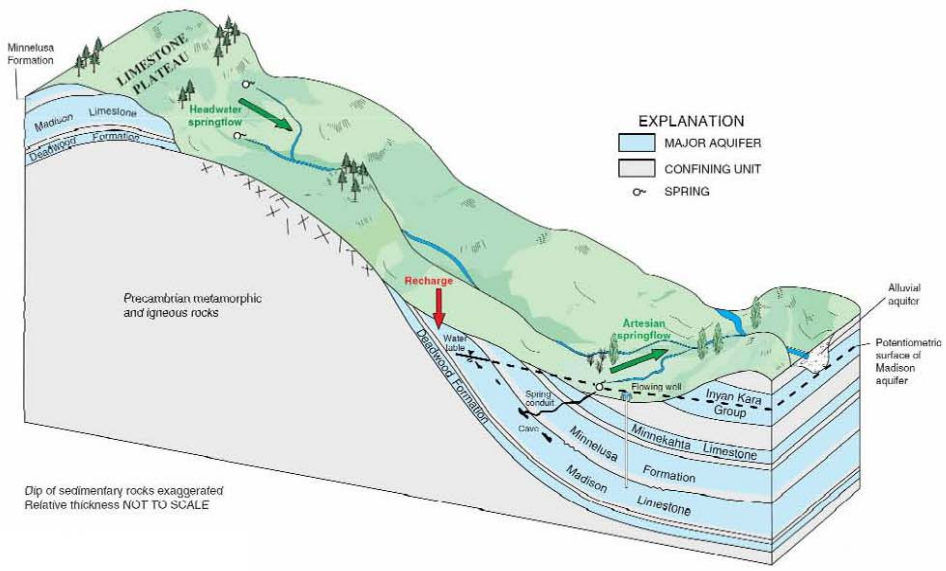

FIGURE 5.1
DIAGRAM SHOWING A SIMPLIFIED VIEW OF THE HYDROGEOLOGIC SETTING OF THE BLACK HILLS AREA
(modified from Driscoll et al, 2002)

DEWEY-BURDOCK PROJECT

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

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Figure 5.1: Diagram Showing a Simplified View of the Hydrogeologic Setting of the Black Hills Area

5.1.1 Regional Hydrostratigraphic Units

This section summarizes the aquifers in the Black Hills, including general characteristics and hydraulic properties. Geologic units of interest within the Black Hills area are shown on the stratigraphic column in Figure 6.2 and detailed information on the geologic units is provided in Section 6.

5.1.1.1 Precambrian Aquifer

The Precambrian rocks that make up the core of the Black Hills consist of various rock types including metamorphosed sedimentary rocks and granites. Precambrian aquifers are not continuous and have little to no primary porosity; "groundwater flow is mainly controlled by secondary permeability caused by fracturing and weathering" (Driscoll et al., 2002). The greater the fracture density, the greater the porosity and permeability that exists, Rahn (1985) estimated the effective porosity of the Precambrian aquifers to be 0.01. In general only the upper 500 feet has been developed, although deeper wells have been completed within the Precambrian (Driscoll et al., 2002). Galloway and Strobel (2000) found that the transmissivity of the Precambrian ranged from 450 to 1,435 square feet per day (ft^2/day). According to Driscoll et al. (2002), "the Precambrian aquifer is mostly unconfined, but may have locally confined conditions."

5.1.1.2 Deadwood Aquifer

Overlying the Precambrian, the Cambrian Deadwood Formation consists of basal conglomerates, sandstone, limestone, and mudstone. The thickness of the Deadwood is between 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 ranges from 250 to 1,000 ft^2/day (Table 2.1) (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).

5.1.1.3 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 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 2.1, Driscoll et al., 2002). 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.

5.1.1.4 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. The Minnelusa aquifer is confined above by the Opeche Shale and below by lower permeability layers at the base of the Minnelusa formation.

5.1.1.5 Inyan Kara Aquifer

Away from the central Black Hills, the Inyan Kara is typically the first significant aquifer encountered. The Inyan Kara aquifer is comprised of two (2) 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 feet thick) and above by Cretaceous Graneros Group shale.

5.1.2 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.

5.1.3 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. 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 variations in yields between areas indicate 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). The historical and recent drilling activities and pumping tests do not indicate the presence of breccias pipes within the project area.

5.1.4 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. The purpose of these maps is to show the potentiometric surface of the aquifers and be a tool for evaluating groundwater flow directions and hydraulic gradients in the Black Hills area. The potentiometric maps were created by contouring altitudes of water levels 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 regional potentiometric surfaces generated by the USGS are provided in Appendix E.

5.2 Site Hydrogeology

This section focuses on Site Hydrogeology in comparison to documented regional values. Regional characteristics of hydrostratigraphic units are presented above; detailed geology is provided in Section 6. Only hydrogeologic units younger than and including the Spearfish Formation (Permo-Triassic age) are described here for two reasons:

1. 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.
2. Federal and State permit guidance requires the assessment focus on the mined unit and hydrogeologic units immediately above and below the proposed mined unit.

5.2.1 Site Hydrostratigraphic Units

The site hydrostratigraphic units are generally consistent with regional units discussed above. However, there are some site specific differences in geological features such as historical and recent drilling activities that have not indicated the presence of breccias pipes within the project area. The recent pumping tests have not indicated any communication with the Unkpapa within the proposed permit area.

5.2.1.1 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 Dewey-Burdock area, 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.

5.2.1.2 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 Dewey-Burdock area. The Sundance Formation is composed primarily of shale and sandstone with an average thickness of 280 feet thick near Dewey-Burdock. 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.

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

5.2.1.4 Inyan Kara Group

The Inyan Kara Group is the principal aquifer in the region of the PAA. 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 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 (TVA, 1979). It is possible that, "interaquifer connection here could result from as-yet-unidentified structural features or old open exploration holes" (TVA, 1979). However, as-yet-unidentified structural features or old open exploration holes have not been confirmed through detailed mapping of the numerous drill holes throughout the PAA. The Inyan Kara is treated in the TVA 1979 reports 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.

5.2.1.5 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. The Skull Creek and Mowry are overlying in the project area, however, the Newcastle is missing and the Belle Fourche crops out to the west. In the Dewey-Burdock area, the thickness of the Graneros is zero (0) at the outcrop but increases westward to more than 500 feet thick. The Skull Creek Shale has a thickness of approximately 200 feet and is the upper confining unit for the Project. Core samples were collected from the lower Skull Creek shale; analyses of these core samples demonstrate that the Skull Creek clays have extremely low vertical permeabilities, in the range of 6.8×10^{-9} cm/sec (0.007 millidarcies).

5.2.1.6 Alluvial Aquifers

For the purpose of this report, the alluvial aquifers in the vicinity of the Dewey-Burdock Site consist of any saturated alluvial material along Pass Creek, Beaver Creek, and the Cheyenne River. In general, the thickness of the alluvial material varies from zero (0) to 25 feet, although it can reach 40 feet. Based on water level measurements in five alluvial piezometers, the upper 10 to 15 feet of the alluvium is unsaturated. The alluvial material is typically unconfined although localized areas of confinement may exist where weathered shale and other material has slumped on top of the alluvium.

6.0 Attachment F - Maps and Cross Sections of Geologic Structure of Area

The following attachment includes project scale maps and cross sections that show detailed geologic structure affecting local stratigraphy, lithology of injection intervals and lithology of confining intervals. Supporting information is provided.

6.1 Regional Geology

The PA is located in the Great Plains Physiographic province on the south-western flank of the Black Hills uplift in south-western South Dakota. To the west of the project area is the Powder River Basin of Wyoming. The regional geologic map of this region is shown in Figure 6.1.

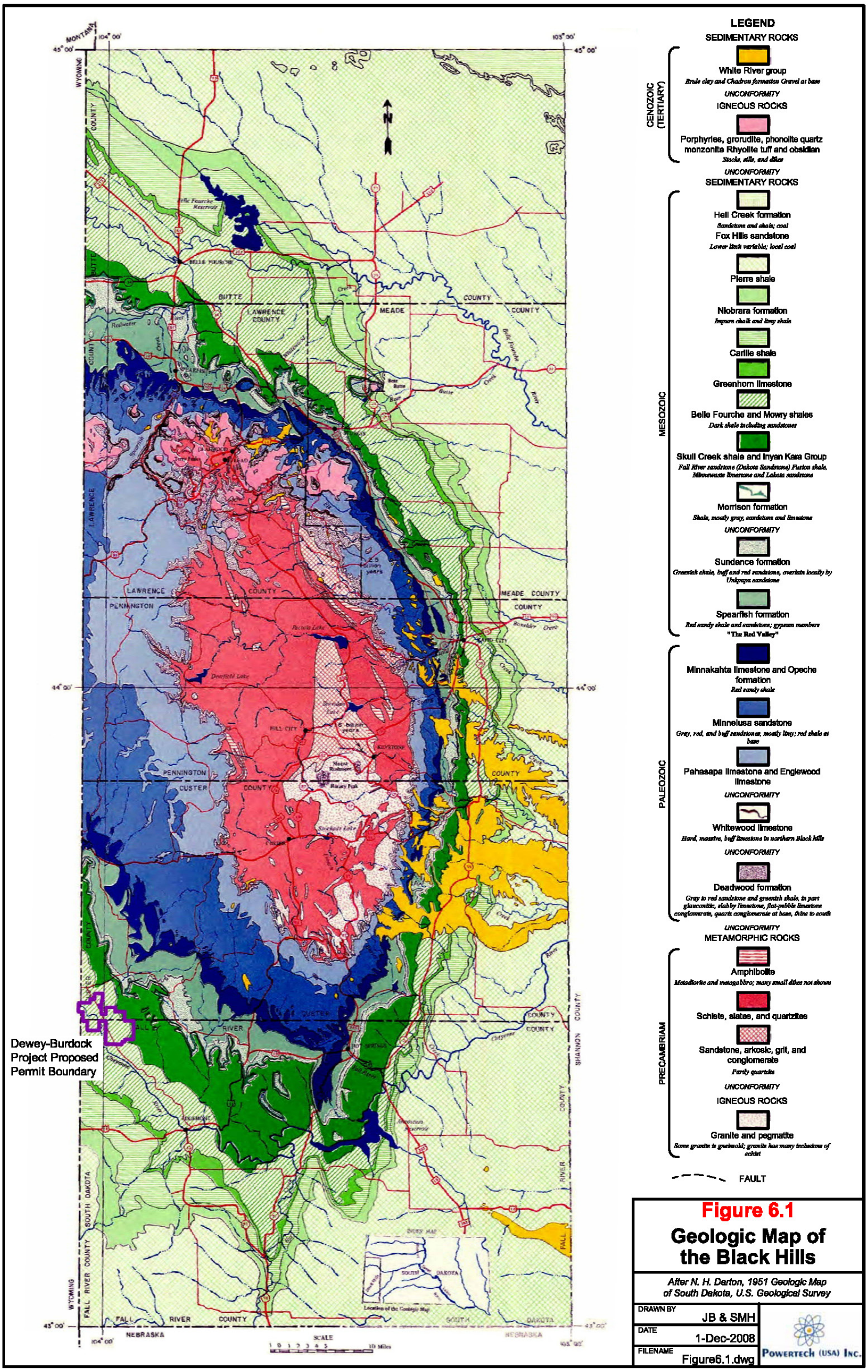

Figure 6.1: Geologic Map of the Black Hills

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 rocks 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.

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.

A stratigraphic column of the Black Hills is illustrated in Figure 6.2.

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	[1]80-300	Impure chalk and calcareous shale.
			CARLILE SHALE — Turner Sandy Member Wall Creek Member	[1]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	[1]25-65	Thin to medium-bedded, fine-grained, purplish gray laminated limestone.
		Po	OPECHE SHALE	[1]25-150	Red shale and sandstone.
		PIPm	MINNELUSA FORMATION	[1]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.
	PENNSYLVANIAN				
	MISSISSIPPIAN	MDme	MADISON (PAHASAPA) LIMESTONE	[1]<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	[1]0-235	Buff dolomite and limestone.
			WINNIPEG FORMATION	[1]0-150	Green shale with siltstone.
	CAMBRIAN	O€d	DEADWOOD FORMATION	[1]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.

[1]Modified based on drill-hole data

FIGURE 6.2
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 6.2: Stratigraphic Column of the Black Hills Area

6.2 Site Characterization

6.2.1 Stratigraphy

The sedimentary rocks of primary interest that underlie the PAA 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 6.1 is a generalized cross section of the project area, illustrating the relationship between these sedimentary units, as well as their position to underlying rocks, ranging in age from Jurassic to Precambrian.

6.3 Overlying Units: Mowry Shale and Skull Creek Shale Formations

Mowry Shale

At the PAA 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 project area. 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 PAA. Plate 6.2 is an isopach map showing the combined thickness of these two shale units. In the north-eastern 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 area 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.

Skull Creek Shale Formation

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 an average 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 x 10^{-9} cm/sec (0.007 millidarcies). The Skull Creek Shale is eroded from the eastern parts of the project.

6.4 Production Zone Units: Fall River and Lakota Formations

Inyan Kara Group

The Early Cretaceous Inyan Kara Group consists of two formations, The Lakota and the Fall River. The Inyan Kara is composed of interbedded sandstone siltstone and shale. Sandstones within these two formations are hosts to all the uranium mineralization for the PA. The depositional environment of the Inyan Kara is fluvial to marginal marine.

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 PAA 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 (Plate 6.3) shows a range of thickness of 120 to 160 feet. The thickening of the formation indicates the presence channel sandstones. Along the north-eastern portion of the project area, this formation is exposed on the surface and erosion has taken place.

Lakota Formation

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

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

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

The isopach map of the Chilson Member (Plate 6.4) 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.

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 2.2×10^{-7} cm/sec to 7.8×10^{-9} cm/sec (0.228 millidarcies to 0.008 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 (Plate 6.5) shows the thickness of the shale – siltstone unit ranging from 30 to 80 feet. It shows thinning of the shale under the overlying channel sandstones of the Fall River Formation. The isopach map (Plate 6.6) of the underlying unit (the Morrison Shale) shows the thickness of the shale ranging from 90 to 115 feet.

6.5 Underlying Unit: Morrison

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 4.2×10^{-8} cm/sec to 3.9×10^{-9} cm/sec (0.043 millidarcies to 0.004 millidarcies).

6.6 Site Geology

The site geology is shown in Figure 6.3. 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.

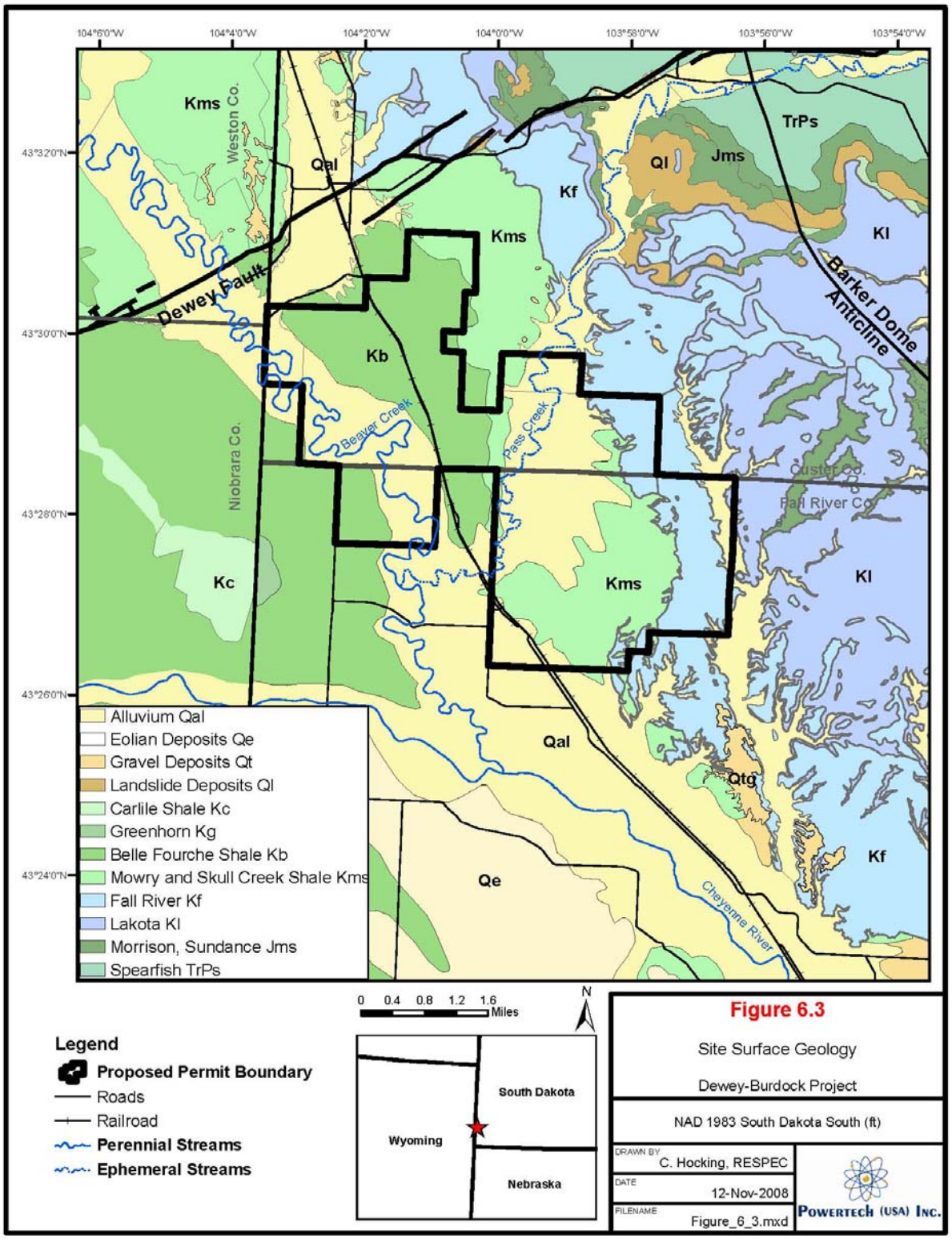

Figure 6.3: Site Surface Geology

The geology of the PAA 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 6.7 is an example of a "type log" from the PAA

Cross sections were generated using a 3-D geologic model, C'Tech's Mining Visualization Systems (MVS) (CTECH, 2008). MVS is a software program that allows a variety of data to be displayed in three dimensions. The objective of this model was to provide detailed geologic maps and cross-sections across the project area.

Cross sections from exploration logs were developed along each ore body and illustrate the aerial distribution of the sandstones across the project. Plate 6.8 shows the locations of the four cross sections. The cross sections were generated in the MVS model and show the stratigraphy across the project area with the ore in the sandstones. The Skull Creek Shale thickens from the east to the west (Plate 6.9). The Fall River Formation is continuous across the area and dips to the west (Plate 6.10). The Fuson Member of the Lakota ranges from 30 to 80 feet across the area (Plate 6.11). The Chilson Member of the Lakota is continuous across the area and thickens and thins due to channels (Plate 6.12). The ore in the Fall River occurs in the lower sandstone unit. The ore in the Chilson Member of the Lakota occurs in the sandstone channels of the member.

6.7 Site Structure

The structure across the project is simple and shows sediments dipping gently 2 to 6 degrees to the southwest. This is illustrated by structure contour maps on the top of the Fall River Formation (Plate 6.13), the Chilson Member of the Lakota Formation (Plate 6.14) and the top of the Unkpapa Formation (Plate 6.15).

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

There is some folding in the areas adjacent to the PAA. 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.

There are no known geologic structural issues within the PAA that would compromise the surface or subsurface concerning development of the proposed action. 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 (Hammond, 1992). 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 kilometers (200 miles) to the west-southwest.

7.0 Attachment H - Operating Data

The following attachment discusses the uranium ISL process and provides a detailed overview of the PA operating data.

7.1 Chemical Storage, Solution Mining Method and Recovery Process

The ISL process requires chemical storage and feeding systems to store and feed chemicals at various stages in the extraction, processing and waste treatment processes. Each chemical storage system will be designed to safely store and accurately deliver process chemicals to their intended delivery point in the process. Design criteria for chemical storage and feeding systems include applicable sections of the international building code, international fire code, Occupational Safety and Health Administration (OSHA) regulations, Resource Conservation and Recovery Act (RCRA) regulations, and Homeland Security rules. Both the Dewey and Burdock sites will have outside storage tanks for carbon dioxide and oxygen (Figure 7.1 and Figure 7.2). At the Burdock site, additional outside storage tanks will be provided for storage of hazardous chemicals including acids, hydrogen peroxide, propane and sodium hydroxide. Additional storage tanks inside the central processing plant will be provided for the more innocuous elution salts that are transported to the site as dry solids.

The general process of in situ recovery involves the oxidation of reduced uranium from an ore-bearing aquifer using a leaching solution (lixiviant) to solubilize the uranium ion. In the U.S. lixiviants, most commonly used, are alkaline solutions prepared using natural groundwater fortified with a carbonate/bicarbonate complexing agent and gaseous oxygen as an oxidizing agent. The uranium-rich (pregnant) lixiviant is pumped back to the surface through recovery wells. After recovery of the uranium on ion exchange resin, the now barren lixiviant (fresh water) is pumped back to the well field to be reinjected into the injection wells in the well field, thus recycling the natural groundwater.

The pregnant lixiviant is pumped to the ion exchange columns located in the central processing plant or in the satellite ion exchange facility. In the ion exchange columns, the uranium is adsorbed onto resin beads that selectively remove uranium from solution. At the central processing facility, the uranium is eluted (stripped) from the resin with a solution of salt (NaCl) and soda ash (Na_2CO_3), precipitated by hydrogen peroxide (H_2O_2), filtered, dried and packaged as yellowcake (U_3O_8). Barren lixiviant is recharged with carbonate/bicarbonate and oxygen and returned through the injection wells to dissolve additional uranium.

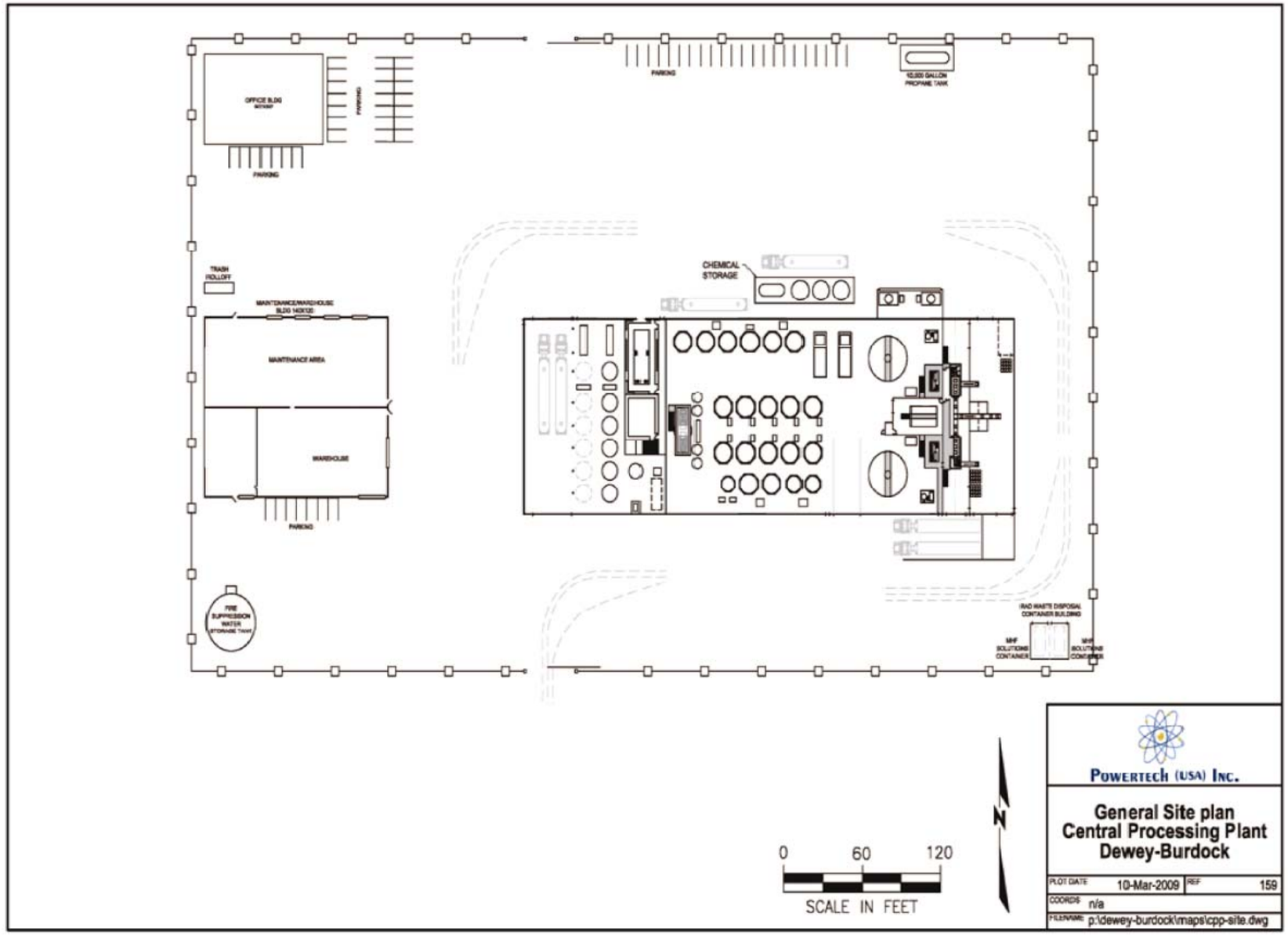

Figure 7.1: General Site Plan Central Processing Plant

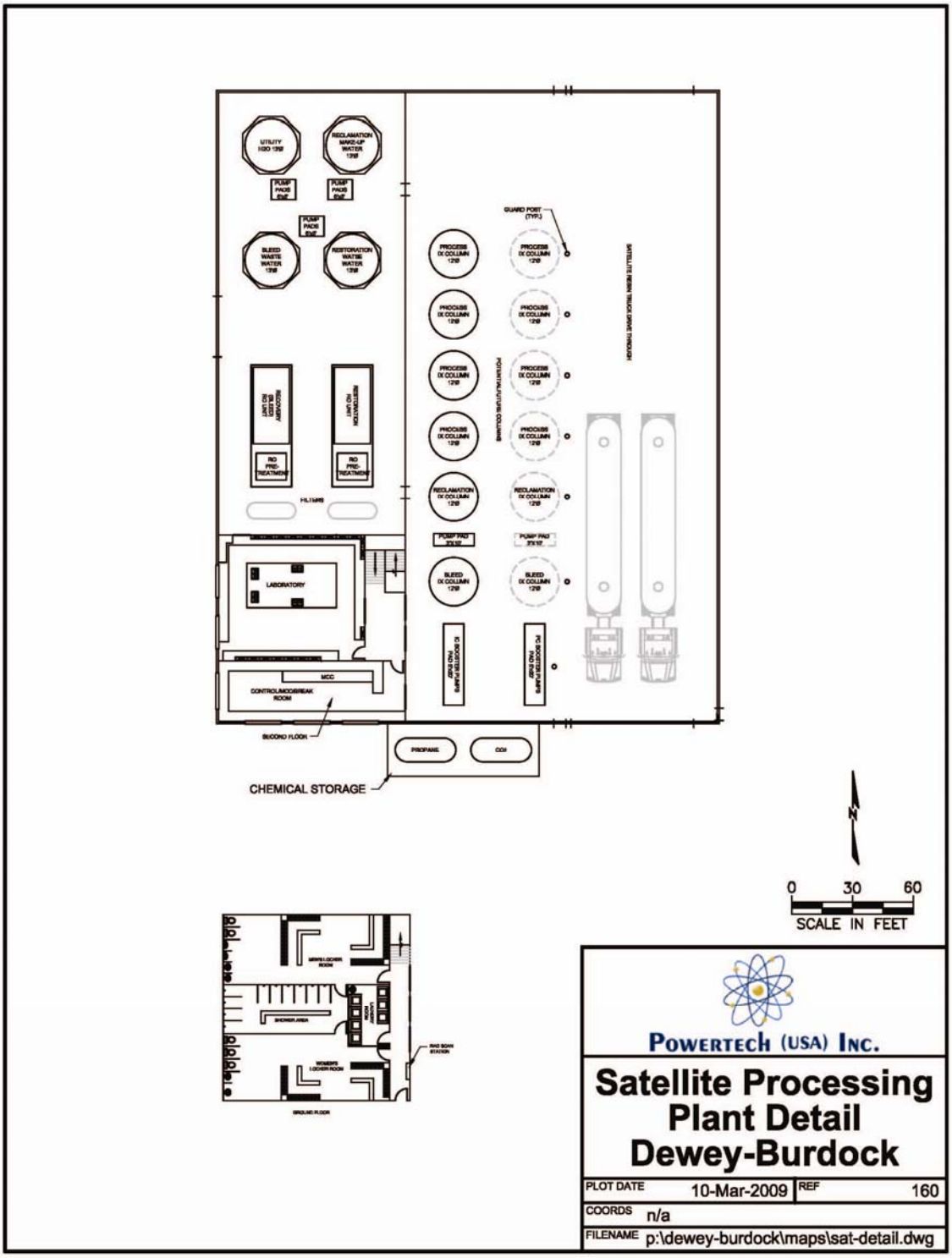

Figure 7.2: Satellite Processing Plant Detail

Approximately 0.5 to 3.0 percent of the barren lixiviant, referred to as the production bleed, is removed from the circuit, and sent to wastewater disposal. The production bleed ensures that more groundwater is extracted than re-injected, maintaining a cone of depression surrounding the network of wells. Maintaining this negative water balance serves to ensure that there is a net inflow of groundwater into the well field to prevent the potential movement of lixiviant and the associated contaminants out of the well field.

The bleed stream will be separated from the bulk flow of lixiviant in a reverse osmosis process that separates a portion of the lixiviant flow into two streams: A relatively clean permeate stream and a reject brine that contains a higher level of dissolved solids, including radium and other contaminants. The reverse osmosis permeate stream is combined with the barren lixiviant for re-injection into the well field, while the reject brine will be directed to disposal in a Class I or Class V disposal well, or to disposal by land application. If no disposal wells are available within or nearby the permit boundary, the alternate waste water disposal method of land application will be used. In this latter case, the bleed stream will not be concentrated through a reverse osmosis process, but will be treated with additional ion exchange to remove residual uranium, followed by contact with barium chloride to remove radium. Other treatments may also be required before the bleed stream would be applied to the land through center-pivot irrigation systems to grow an agricultural crop.

7.2 Dewey-Burdock Well Field Operation

The PA will operate uranium ISL production facilities at both the Dewey and Burdock sites with a central processing plant located at the Burdock site. The Dewey-Burdock ISL well fields will consist of either 5-spot or 7-spot patterns. A typical 5-spot pattern contains four injection wells and one production well. The well fields will be based on 70x70-foot or 100x100-foot grids where injection wells will be spaced 70 or 100 feet apart depending on the chosen grid. The wells will be completed so that they can be used as either injection or production wells. A typical (100 x 100-foot grid) well field is shown on Plate 7.1.

The estimated maximum instantaneous injection flow rate is 4,200 gpm; the system is designed to operate at 4,000 gpm to produce 1 million pounds of U_3O_8 per year at the estimated average uranium concentration. However, the flow rate will be adjusted to maintain desired production levels. The injection pressure will be designed to be less than formation fracture pressure. The flow is nominal and controlled via injection booster pumps and manual flow control valves on the injection wells.

Injection pressure will not exceed the formation fracture pressure and 80 percent of the minimum material strength of piping components. Pressure at the header house will be limited to the lowest mechanical integrity test passing pressure; therefore, will not exceed the published operating pressure for any piping component in the system. Average injection pressure at the pump discharge is estimated at 82 pounds per square inch gauge (psig).

It is anticipated that the ISL well fields at each site (Dewey or Burdock) will operate at an estimated flow rate between 1500 gpm to 2000 gpm. Uranium extracted from well fields at the Dewey site will be loaded onto ion exchange resins and transported to the Burdock site for elution, precipitation, drying and packaging.

7.2.1 Header House Control

Within each well field, injection and production wells will be connected to manifolds in a nearby header house (Plate 7.2). The manifolds will be connected to a series of pipelines that will carry solutions to and from the satellite facility or central processing plant (Plate 7.3). The manifolds will be visually inspected once a day. The wellheads will be visually inspected once a day. Meters and control valves will be installed in the individual well lines to monitor flow rates and pressures. The individual well flows and pressures will be monitored and adjusted daily with a digital recorder in order to balance individual patterns so that the flow rate from a pattern is less than the flow rate to the pattern, thus maintaining uniform distribution of leach solution and a cone of depression for each individual pattern. Flow meters will also be installed on the main pipelines entering and exiting each header house and monitored continuously. The pipeline pressures will be monitored continuously for indications of spills and leaks.

7.2.2 Detection and Cleanup of Piping Leaks

Leak detection will be performed by daily visual inspection of all above-ground pipe, connections, and fittings by field personnel during their daily site inspections. Operating pressures of all injection wells, recovery wells, and associated buried piping systems will also be monitored during these inspections. In addition, the pressure and flow in each line will be continuously monitored with results relayed to a central processing unit that is connected to a central alarm at the CPP. Should pressure/flow fluctuate outside of “normal” operating ranges, the affected line will automatically shut down and an alarm for operator intervention will activate. An operator will then inspect the troubled component and determine the root cause and extent of

the problem. The troubled component will then be repaired, tested, and returned to service, as appropriate, and preventative measures will be implemented to prevent a recurrence.

Cleanup will involve characterizing the extent of release via visual observation coupled with sampling of soils for constituents of concern in accordance with a standard operating procedure. To the greatest extent practicable, impacted material will be consolidated into a centralized area to mitigate the potential for proliferation of small waste disposal sites within the license area.

7.2.3 Pressure and Flow Rate

The individual well field patterns are balanced daily by adjusting injection and production well flow rates and pressures. Production flow rates will be maintained greater than injection in each pattern and so that flow will be uniformly distributed in each pattern. Each pattern will have withdrawal greater than the injection to prevent outward flow of leach solution from each pattern. The fluid volume for each well will be determined by monitoring the individual flow meters.

- Production flow rates are estimated at 20 to 30 gpm per well.
- Fluid Volume – Daily maximum volume would not exceed 6.05 mgd.
- The estimated maximum instantaneous injection flow rate is 4,200 gpm; most of the time the system will be maintained at a rate of 4,000 gpm.

The maximum injection pressure at the wellhead will not exceed formation fracture pressure. This pressure will not initiate new fractures or propagate existing fractures in the injection or confining zone or cause the migration of injection or formation fluids into any USDW.

7.2.4 Proposed Lixiviant

The efficiency of uranium ISL will, in part, depend on proper selection of the solution lixiviant used to recover uranium from the ore body. The ideal lixiviant will oxidize uranium in the ore and will contain a complexing agent that will dissolve and form strong aqueous complexes that interact little with the host rock (Davis and Curtis, 2007).

The PA proposes to use an alkaline lixiviant that is based on carbonate/bicarbonate added as sodium bicarbonate or carbon dioxide gas as the complexing agent and gaseous oxygen gas as the oxidizing agent. Native groundwater will be circulated through the ore zone and the ion exchange columns with the addition of carbon dioxide and oxygen to oxidize and to complex the

uranium to Uranyl Carbonate with is both soluble and recoverable on the ion exchange resin. The PA proposed lixiviant is presented in Table 7.1.

Table 7.1: Typical Lixiviant Composition

Constituent	Units	Concentration Range	
		Minimum	
Calcium	mg/L	≤20	Calcium
Sodium	mg/L	≤400	Sodium
Magnesium	mg/L	≤3	Magnesium
Potassium	mg/L	≤15	Potassium
Chloride	mg/L	≤200	Chloride
Carbonate	mg/L	≤0.5	Carbonate
Bicarbonate	mg/L	≤400	Bicarbonate
Sulfate	mg/L	≤400	Sulfate
Uranium	mg/L	≤0.01	Uranium
Vanadium	mg/L	≤0.01	Vanadium
pH	Std units	≤6.5	pH
Total Dissolved Solids, TDS	mg/L	≤1650	Total Dissolved Solids, TDS

Notes:

Table adapted from USNRC (2008) Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities-Draft Report for Comment. NUREG-1910. July 2008.

Insoluble minerals such as uraninite (UO_2(solid)) and coffinite ($USiO_4$(amorphous)) will undergo oxidation from the U^4+ to U^6+ oxidation state following injection of lixiviant into the ore body. The oxidative dissolution of uraninite can be written in terms of the following reactions:

$$UO_2(s) + ½O_2 = UO_3(s) \quad [1]$$

$$UO_3(s) + 2H^+ = UO_2^{2+} + H_2O \quad [2]$$

which can be simplified into the overall reaction:

$$UO_2(s) + 2H^+ + ½O_2 = UO_2^{2+} + H_2O \quad [3]$$

The uranyl oxyanion (UO_2^{2+}) forms stable soluble uranyl carbonate complexes such as illustrated in the following reactions:

$$UO_2^{2+} + 3CO^{2-}{}_3 = UO_2(CO_3)_3^{4-} \quad [4]$$

$$UO_2^{2+} + 3HCO^-_3 = UO_2(CO_3)_3^{4-} + 3H^+ \quad [5]$$

$$UO_2^{2+} + CO^{2-}_3 = UO_2(CO_3)_2^{2-} \quad [6]$$

The solubility of each uranyl carbonate species is a function of pH (measure of acidity), Eh (measure of oxidation potential) and the concentration of carbonate/bicarbonate ions in the leaching water (lixiviant). The uranium aqueous complexes will be recovered by passing the pregnant lixiviant with 10 to 900 parts per million uranium in solution, through columns containing ion exchange resin beads. The complexed uranium is exchanged with another anionic species (usually Cl^-) at the reactive resin sites (represented as R^+ where $R^+ + Cl^- = RCl$) as shown in Reaction 7 using the uranyl dicarbonate complex ($UO_2(CO_3)_2^{2-}$):

$$UO_2(CO3)^{2-}_2 + 2RCl = 2R\text{-}UO_2(CO_3)_2 + 2Cl \quad [7]$$

The barren lixiviant will be refortified with carbonate/bicarbonate before being reinjected into the mining zone.

A qualitative analysis of the PA lixiviant, including ranges of concentrations of constituents, will also be reported at least once within the first year of authorization and thereafter whenever the mining solution is modified to the extent that the initial data become incorrect or incomplete.

8.0 Attachment I - Formation Testing Program

The following attachment provides a description of the formation testing program for the PA. The formation testing program conducted includes information about geohydrologic properties of the mining zone and the confining zones as well as physical and chemical characteristics of the formation fluids.

8.1 Fracture Pressure

Powertech does not intend to utilize hydraulic fracturing within the company's ISL process. Consequently, no testing is intended. Powertech intends to operate its injection wells below the fracture pressure of formations where injection occurs. It is crucial for effective operation to maintain the native state of the formations in order to control lixiviant, especially within the existing confining units. This approach reduces the potential for damaging the formation layers and aids in preventing additional pathways for lixiviant. Therefore, due to the fact that such testing tends to increase the probability of creating confinement issues within the well field and the ISL mining process in general, no fracture testing is planned.

Fracture pressure varies with depth of well, specific gravity of rock type within the formation, and the pressure of overburden. Hydraulic pressure is the sum of surface pressure and pressure of the weight of the fluids contained in the wellbore. This sum is multiplied by depth:

Downhole psig = surface psig + (fluid gradient, psi/ft) (depth, feet)

Downhole injection pressures will be maintained below the formation fracture pressure.

Lixiviant used in this mining process has very near the same specific gradient as water (0.433 psi/ft). Therefore, maximum well head pressure (Max WHP) will not exceed the formation fracture pressure and will be calculated utilizing the industry accepted formula:

Max WHP= (fracture gradient – wellbore fluid gradient) (depth to open interval)

Fracture gradient is defined by the EPA as "a measure of how the pressure required to fracture rock in the earth changes with depth. It is usually measured in units of "pounds per square inch per foot" (psi/ft) and varies with the type of rock and the stress history of the rock. The default value used by Region 5 in Michigan is 0.8 psi/ft. This means, for example, that at a depth of

100 ft, a pressure of 80 psi would be required to fracture the rock, while at a depth of 500 ft, the required pressure would be 400 psi; at 1000 ft, 800 psi. The fracture gradient is used in the calculation of the maximum injection pressure."

The maximum allowable WHP will be calculated on a well-by-well basis and operational controls will be put in place to prevent exceeding designated pressures. The maximum WHP accepted will be the lesser value determined for calculated WHP via fracture gradient and depth or that determined from MIT casing results. Wellhead surface injection pressure will be determined for each header house and posted near the injection trunk line gauge nearest to the injection wellhead and used to monitor injection pressure. This practice will ensure the formation fracture pressure is not exceeded according to § 144.28(f) (3) (i) or (ii). The formation fracture pressure proposed to be used for the project is 0.70 psi for every 1 foot of depth to the top of the screened interval. The depth to the top of the anticipated screened interval varies from approximately 200 to 600 feet in well fields at the PAA.

8.2 Pumping Tests

Appendix F provides a complete report documenting previous TVA and recent (2008) pumping tests at the project area. A summary from the report in Appendix F is provided below.

8.2.1 Summary of Previous Pumping Test Results

The TVA conducted groundwater pumping tests from 1977 through 1982 as part of a uranium mine development project near the towns of Edgemont and Dewey, South Dakota. TVA produced two summary pumping test reports, "Analysis of Aquifer Tests Conducted at the Proposed Burdock Uranium Mine Site" (Boggs and Jenkins, 1980) and "Hydrogeologic Investigations at Proposed Uranium Mine near Dewey, South Dakota" (Boggs, 1983). In addition, TVA prepared a draft Environmental Impact Statement for the proposed Edgemont Uranium Mine in 1979.

TVA first conducted two unsuccessful tests in 1977 at the Burdock test site. The results of the 1977 tests were considered inconclusive because of various problems including questionable discharge measurements, some observation wells improperly constructed, and some pressure gauges malfunctioned. No data from the 1977 tests are currently available.

TVA conducted three successful pumping tests, two in 1979 near the current Burdock Project Area, and one in 1982 about 2 miles north of the current Dewey Project Area. The results of

these successful tests are described in separate sections, below. However, no data for these tests, in particular electronic records of drawdown, are available, other than information contained in the reports.

Dewey Project Area

The Dewey test was conducted in 1982 northeast of the Dewey Road at the location shown on Figure 8.1. The test consisted of pumping in the Lakota formation for 11 days at an average rate of 495 gpm. The test developed the following information:

- Transmissivity of the Lakota averaged about 4,400 gallons per day per foot (gpd/ft) which is equivalent to 590 feet squared per day (ft^2/day).
- Storativity of the Lakota was about 1.0×10^{-4} (dimensionless).
- There was response between the Fall River and Lakota formations through the intervening Fuson shale-siltstone member, that was manifested at relatively late time (3000 to 10000 minutes).
- The vertical hydraulic conductivity of the Fuson aquitard using the Neuman-Witherspoon ratio method (Neuman and Witherspoon, 1973) was 2×10^{-4} ft/day; storativity of the Fuson Member was not determined and specific storage was about 7×10^{-7} ft^{-1}.
- A barrier boundary, or a decrease in transmissivity due to lithologic changes with distance from the test site, or both, were observed; a possible geologic feature corresponding to a barrier was noted to be the Dewey Fault Zone, located about 1.5 miles north of the test site, where the Lakota and Fall River formations are structurally offset.

Burdock Project Area

The Burdock tests were conducted in 1979 near the Dewey road at the location shown on Figure 8.1. The Burdock tests consisted of separate pumping tests from the Lakota (Chilson) and Fall River Aquifer, respectively in April and July of 1979. The tests used the same pumping well with packers to alternately isolate screens open to the respective formations. Test durations were 73 hours for the Lakota test and 49 hours for the Fall River test. Pumping rates were about 200 gpm from the Lakota aquifer and 8.5 gpm from the Fall River. The reason for the unexpected low pumping rate from the Fall River aquifer was not specified in the TVA report.

The tests developed the following information:

- Interpreted transmissivity of the Lakota was based on analysis of later time data and inferred decreasing transmissivity with distance from the test site due to changes in lithology; overall transmissivity averaged about 1,400 gpd/ft (190 ft^2/day) and storativity about 1.8 x 10^{-4} (dimensionless); maximum transmissivity from early time data was about 2,300 gpd/ft (310 ft^2/day).

- Transmissivity of the Fall River averaged about 400 gpd/ft (54 ft^2/day) and storativity about 1.4 x 10^{-5} (dimensionless).

- There was communication between the Fall River and Lakota formations through the intervening Fuson shale-siltstone member; leaky behavior was observed in the Fall River formation and believed to exist in Lakota although "leakage effects in the Lakota drawdown data are masked by the conflicting effect of a decreasing transmissivity in site vicinity" (p. 16 in Boggs and Jenkins, 1980).

- The vertical hydraulic conductivity of the Fuson aquitard the Neuman-Witherspoon ratio method (Neuman and Witherspoon, 1973) ranged from 10^{-3} to 10^{-4} ft/day; storativity was not determined, and specific storage was assumed to be about 10^{-6} ft^{-1}.

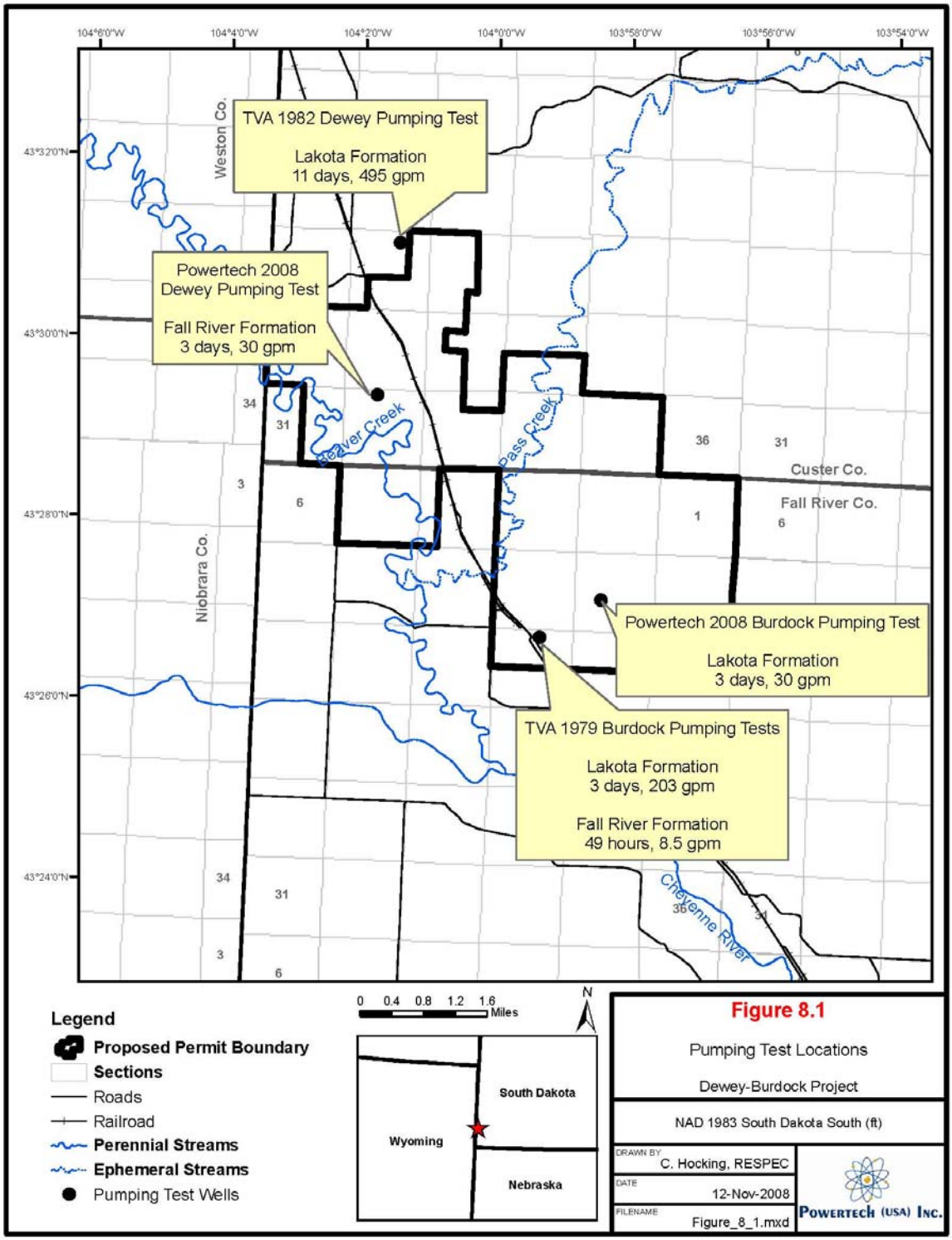

Figure 8.1: Pumping Test Locations

8.2.2 2008 Pumping Tests

In 2008 pumping tests were performed at both the Dewey and Burdock project areas, along with laboratory tests on related core samples, to determine aquifer properties at the site. A work plan (Knight Piésold, 2008b) was prepared and distributed to interested representatives of state and federal agencies, including the SD DENR and the EPA.

A detailed description of the aquifer testing methodology and analysis of the results are contained in the aquifer test report (Knight Piésold, 2008c), which is contained in Appendix A of the Pumping Test Report (Appendix F). The report results are briefly summarized in the following sections.

8.2.2.1 Burdock Project Area

Summary of Burdock Pumping Test Results

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

- Nine determinations of transmissivity (Table 8.1) ranged from 120 to 223 ft^2/day with the median value of 150 ft^2/day.
- Four storativity determinations (Table 8.1) ranged from 6.8×10^{-5} to 1.9×10^{-4} with the median value of 1.2×10^{-4}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 2,100 feet.
- The pumping well in the lower Lakota formation was determined to be moderately efficient: 80 to 83 percent by the empirical distance-drawdown method and 65 percent by the USGS (Halford and Kuniansky, 2002) theoretical method.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 8.2) were made on sandstone layers similar to that tested in the pump test; measured horizontal hydraulic conductivity ranged from 5.9 to 9.1 ft/day, the mean value was 7.4 ft/day and the mean ratio of horizontal to vertical hydraulic conductivity in Burdock area sandstone (Lakota) was 2.47:1
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 8.2) were made on shale layers from the two major confining units for the Lakota formation in the pump test area with the following results:

- Fuson Shale: the laboratory core data indicate vertical permeabilities of about 2×10^{-7} to 1×10^{-8} cm/sec (average 2.7 x 10-4 ft/day) for shale samples from within the Fuson member overlying the Lakota formation.

- Morrison Shale: the laboratory core data for the shales in the underlying Morrison formation indicate vertical permeabilities of 9×10^{-9} to 3×10^{-8} cm/sec (average 6.0×10^{-5} ft/day).

- The range of hydraulic conductivities determinable from test transmissivities was 0.9 to 15.0 ft/day, which is considered an appropriate range that is also verified by the sandstone core sample results falling in the middle of the range; it is noted that the lower end of the hydraulic conductivity range is probably appropriate for use with the entire formation thickness (shale layers included) and the upper end represents the most permeable sandstone layers such as the ore zone areas tested in the pump test.

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Table 8.1: Summary of Aquifer Hydraulic Characteristics for the Burdock Pumping Test

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft2/day)	u or u' (unitless)	Storativity (unitless)	Note
Ore zone (lower Lakota Sandstone)							
11-11C	Pumping	0.25 (0.33)	Theis DD(1)	145	-	2.9E-09(a)	-
			CJ DD (3)	150	<0.01	-	-
Pumping Well Efficiency = 65%(3)							
			CJ Recovery (3)	140	<0.01	-	-
15-Nov	Obs #1	243	Theis DD(1)	67	-	1.30E-03	-
			CJ Recovery (3)	100	<0.1	-	-
11-14C	Obs #2	250	Theis DD(1)	128	-	6.80E-05	-
			H-J DD(1)	120	-	6.90E-05	--
			Theis Recovery(1)	174	<0.01	-	-
			CJ Recovery (3)	160	<0.01	-	-
2-Nov	Obs #3	1,292	Theis DD(1)	223	-	1.90E-04	-
			H-J DD(1)	185	-	1.70E-04	-
			CJ Recovery (3)	260	<0.15	-	-
Upper Lakota Sandstone							
19-Nov	Obs	50	Theis DD(2)	260	-	1.00E-01	-
			CJ Recovery (3)	190	<0.15	-	-
Fall River (lower sandstone layer)							
17-Nov	Obs	50	Noordbergum Effect and response cannot be interpreted analytically				
Unkpapa Formation							
18-Nov	Obs	35	No response during pumping test.				-
Distance Drawdown (11-14C, 11-15, 11-02)(2)				145	<0.08	2.20E-04	r2 = 0.76 (3 point line)
Pumping Well Efficiency = 61% to 63%							
Summary:	Median			150		1.20E-04	
Average/Geometric Mean(5)				158		1.12E-04	
	TVA(4)			190		1.80E-04	

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

(2) Knight Piésold spreadsheet after methods in Driscoll (1986).
(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).

(4) Summary values from p. 17 in Boggs and Jenkins (1980).
(5) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.

(a) Storativity not valid at pumping well.

(b) Based on 6 inch casing (8 inch borehole).

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

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Table 8.2: Laboratory Core Analyses at Dewey Burdock Site

			Air Intrinsic			Water Hydraulic		
	Confining		Permeability(1)	Particle		Conductivity(2)(3)	Core	Core
Depth	Stress	Porosity	ka	Density		Kw	Kh	Kv
(ft)	(psig)	(%)	(mD)	(g/cm3)	Notes	(cm/s)	(ft/day)	(ft/day)
Burdock								
252.2	600	10.5	1.04	2.356	Fuson Shale	8.01E-07		
252.35	600	10.15	0.228	2.356	Fuson Shale	1.76E-07		
412.3	600	9.68	0.041	2.511	Fuson Shale	3.16E-08		
412.45	600	9.59	0.015	2.514	Fuson Shale	1.15E-08		
Dewey								
480.7	600	8.9	0.078	2.613	Skull Creek shale	6.01E-08		
480.8	600	9.3	0.007	2.61	Skull Creek shale	5.39E-09		
609.1	600	12.26	0.073	2.603	Fuson Shale	5.62E-08		
609.1	600	10.84	0.008	2.793	Fuson Shale	6.16E-09		
Burdock								
423.6	600	29.56	3,207	2.645	Lakota Sand	2.47E-03	7	
423.35	600	30.34	1,464	2.645	Lakota Sand	1.13E-03		3.2
430.2	600	31.9	4,161	2.64	Lakota Sand	3.20E-03	9.1	
430.35	600	30.16	939	2.646	Lakota Sand	7.23E-04		2.1
453.5	600	10.86	1	2.519	Morrison Shale	7.70E-07		
453.45	600	11.82	0.043	2.543	Morrison Shale	3.31E-08		
Burdock								
420.4	600	30.5	2,697	2.643	Lakota Sand	2.08E-03	5.9	
420.1	600	30.17	1,750	2.651	Lakota Sand	1.35E-03		3.8
455.9	600	6.99	0.004	2.536	Morrison Shale	3.08E-09		
455.45	600	7.65	0.012	2.556	Morrison Shale	9.24E-09		
503.3	600	12.96	0.697	2.474	Morrison Shale	5.37E-07		
503.45	600	No data						
Dewey								
573.25	600	29.15	2,802	2.641	Fall River Sand	2.16E-03	6.1	
573.4	600	29.04	619	2.645	Fall River Sand	4.77E-04		1.4
							7.4	3

Burdock Pumping Test Conclusions

The Burdock pumping test in 2008 may be directly compared to the 1979 TVA test for the Lakota (Chilson) aquifer as the tests were nearly at the same location (Figure 8.1). The average transmissivity and storativity values determined from the TVA tests were 190 ft^2/day and 1.8 x 10^{-4} (see p. 17 in Boggs and Jenkins, 1980). Comparing the median transmissivity of 150 ft^2/day and storativity of 1.2 x 10^{-4} determined in the 2008 test to the TVA test, demonstrates that the new aquifer parameters for the lower Lakota are respectively about 80 and 70 percent of the 1979 results. Because transmissivity and storativity depend on aquifer thickness, comparing the results suggests that there may be some scaling effect between the tests due to the differing lengths of screened intervals.

Therefore, the 1979 TVA test results for transmissivity of 190 ft^2/day is considered representative of the entire Lakota aquifer for a regional application, such as a groundwater flow model where an average hydraulic conductivity of about 1 foot/day over a thickness of 170 feet could be specified. The 2008 test provides specific data at the operational-scale of a prospective ISL well field where local hydraulic conductivities of up to 15 feet/day could be specified for the most permeable ore zones horizons.

Within the Lakota formation, vertical communication throughout the entire formation is indicated by the delayed response at the upper Lakota observation well (11-19). The 160 minute delay in response at the upper Lakota observation well 11-19 is attributed to lateral and vertical anisotropy due to the shale interbeds seen on the conceptual stratigraphic cross-sections for the pump test site (Knight Piésold, 2008c). The extent and continuity of the shale interbeds are unknown. Whether the shale interbeds in the Lakota aquifer are sufficiently thick and continuous to serve as vertical confinement for ISL operations will probably need to be evaluated by analyzing cores from borings as well fields are drilled.

The 2008 test indicates that the lower and upper portions of the Lakota formation behave as a single, confined, leaky aquifer. Confinement and leakage from the overlying Fuson member is evident in the matches to the Hantush-Jacob type curves seen most clearly at observation wells 11-14C and 11-2. These results are more definitive than the 1979 TVA test where confined, leaky behavior for the Lakota was predicted but not demonstrated with curve match results.

Hydraulic communication through the Fuson member between the Lakota and Fall River aquifers is evidenced by the response at observation well 11-17, screened in the lower Fall River

formation. The first response in the lower Fall River is interpreted as a Noordbergum effect where water levels monitored above the pumping zone aquitard temporarily increased due to three-dimensional deformation caused by ground water withdrawal from a confined aquifer (Hseigh, 1997). The Noordbergum effect appears characteristic of the Inyan Kara formation based on its occurrence in a 1985 pumping test in the Eastern Black Hills near Wall, South Dakota (Rahn, 1985) and also the previous TVA test at the Burdock site (Boggs and Jenkins, 1980). However, drawdown continued at the Fall River observation well 11-17, indicating that leakage was established through the underlying Fuson formation.

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

The potentiometric surface in the Fall River aquifer is close to that in the Lakota aquifer at the Burdock pump test site, indicating some local connection between the two formations through the intervening Fuson member. In other locations in the Inyan Kara, the Fuson member is known to have sandstone layers that are downcut into the Lakota member (Gott et al., 1974). Therefore, determining the degree of vertical confinement for ISL operations by the Fuson will probably need to be evaluated by analyzing cores from borings as well fields are drilled, and with well field-scale pumping tests that are proposed to be conducted prior to start-up of each particular mine unit.

The aquifer tests in 1979 and 2008 indicate that the Lakota formation is a confined aquifer with a leaky confining layer, which is demonstrably the Fuson member. The laboratory core data for the shales in the underlying Morrison formation indicate an average vertical permeability of 2.1×10^{-8} cm/sec (6×10^{-5} ft/day). Together with the pump test data, the core data indicate that the underlying Morrison formation and overlying Fuson member can serve as confining units for ISL operations.

For the Lakota sandstone, the laboratory core data indicate an average horizontal hydraulic conductivity of 7 ft/day, and as high as 9.1 ft/day. Interpretation of the test results calculates that horizontal permeability may be as great as 15 ft/day throughout one of the ore zones. Within the

lower Lakota formation, the test results indicate transmissive response between pumping and observation wells up to 250 feet apart with 17 feet of drawdown. Response was nearly 3 feet of drawdown at 1,290-foot distance. This indicates the aquifer was stressed to produce good quality analytical results.

8.2.2.2 Dewey Project Area

Summary of Dewey Pumping Test Results

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

- Ten determinations of transmissivity (Table 8.3) ranged from 180 to 330 ft^2/day with the median value of 255 ft^2/day.
- Five storativity determinations (Table 8.3) ranged from 2.3×10^{-5} to 2.0×10^{-4} with the median value of 4.6×10^{-5}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 5,700 feet.
- The pumping well in the Fall River formation was determined to be highly efficient: 93 to 95 percent by the empirical distance-drawdown method and 81 percent by the USGS (Halford and Kuniansky, 2002) theoretical method.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 8.2) were made in core sample from the sandstone layer similar to that tested in the pump test; measured horizontal hydraulic conductivity was 6.1 ft/day, and the ratio of horizontal to vertical hydraulic conductivity was 4.5:1.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 8.2) were made on shale samples from the two major confining units overlying and underlying the pump test area with the following results:
  - Skull Creek shale: laboratory core data for the shale sample from the overlying Skull Creek formation indicate a vertical permeability of 5.4×10^{-9} cm/sec (1.5×10^{-5} ft/day).
  - Fuson Formation: laboratory core data for the shale sample from the underlying Fuson formation indicate a vertical permeability of 6.2×10^{-9} cm/sec (1.8×10^{-5} ft/day).

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Table 8.3: Summary of Aquifer Hydraulic Characteristics for the Dewey Pumping Test

Dewey Test Site Pumping Test Interpretations							
Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft2/day)	u or u' (unitless)	Storativity (unitless)	Note
Ore zone (lower Fall River Sandstone)							
32-3C	Pumping	0.25 (0.33)	Theis DD(1)	250	-	1.2E-06(d)	-
			CJ DD (3)	250	<0.01	-	-
Pumping Well Efficiency = 80%(3)							
			CJ Recovery (3)	270	<0.01	-	-
32-5	Obs #1	243	Theis DD(1)	294	-	3.30E-05	--
			Theis Recovery(1)	260	<0.01	-	-
			CJ Recovery(3)	280	<0.01	-	-
32-4C	Obs #2	467	Theis DD(1)	333	-	5.60E-05	-
			CJ Recovery (3)	120(a)	<0.01	-	
29-7	Obs #3	2,400	Theis DD(2)	178	-	2.00E-04	
			CJ Recovery (3)	Insufficient recovery for analysis			-
Fall River Aquifer Stock Well (Screened in top half of Fall River)							
GW-49	Stock	1,400	Theis DD(1)	177	-	2.30E-05	-
			CJ Recovery (3)	110	<0.05	-	-
Upper Fall River Sandstone							
32-9C	Obs	41	Theis DD(1)	217	-	1.60E-02	-
			CJ Recovery (3)	150	<0.05	-	--
Lakota Sandstone Layer							
32-10	Obs	61	No response during pumping test.				--
Unkpapa Formation							
32-11	Obs	50	No response during pumping test.				-
Distance Drawdown (32-5, 32-4C, 29-7, GW-49)(2)				218	<0.05	4.60E-05	r2 = 0.78 (4 point line)
Pumping Well Efficiency = 93% to 95%							
							-
Summary:	Median			255		4.60E-05	
Average/Geometric Mean(4)				251		5.23E-05	

Notes/References: DD = drawdown, CJ = Cooper -Jacob, Obs = Observation Well
(1) Calculated by automated curve fitting in AquiferWin32™ software (ESI, 2003).
(2) Knight Piésold spreadsheet after methods in Driscoll (1986).
(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).
(4) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.
(a) Only slope satisfying u 'criterion occurs after intersection with barrier boundary.
(b) Not accepted due to anomalous response at well, see text.
(c) Storativity not valid at pumping well
'251' = Accepted value based on conformance with theory discussed in Section 5.0 of Appendix F.

Dewey Pumping Test Conclusions

The Dewey pumping test in 2008 in the Fall River aquifer is not directly comparable to the 1982 TVA test because the underlying Lakota aquifer was tested in 1982. As demonstrated above for the Lakota aquifer (Section 8.2.2.1), a scaling effect may be assumed between total formation transmissivity and storativity (i.e., regional-scale) and the 2008 operational-scale test. However, there are several lines of evidence that the 2008 test transmissivity and storativity results are representative of the entire Fall River aquifer at the Dewey test site, as follows:

- Thickness of the sandstone layer screened by the pumping well is about one-half the total formation thickness (see drawings 4.1 and 4.2 in Knight Piésold, 2008c).
- Response at the stock tank well (GW-49 at 1,400-foot distance) was within the acceptable range for a confined aquifer; this is interpreted to indicate that the effects of partial penetration (due to elevation differences between the pumping well screen and the observation well open to the upper half of the aquifer) were diminished at the 1,400-foot distance and 40 minute response time.
- The delay in response at the upper Fall River observation well 32-9C was a relatively brief 11 minutes (see Table 4.2 in Knight Piésold, 2008c), compared to 160 minutes in the Burdock test; together with (2) above, these responses suggest that the vertical anisotropy due to shale interbeds overlying the lower sandstone layer does not extend laterally for more than about 1,400 feet.

The 2008 test indicates that the lower and upper sandstone portions of the Fall River formation behave as a single, confined, aquifer with some form of lateral barrier due to changing lithology, such as a channel boundary. The TVA test in 1982 observed a barrier boundary in the underlying Lakota formation which was attributed to either a change in lithology or the Dewey Fault zone. Apparently, both the Lakota and Fall River formations in the general Dewey project area are highly transmissive and show barrier boundaries. These test results are more definitive than the 1982 TVA test concerning the proximity of the barrier boundary, because the 2008 radius of influence was about one mile compared to greater than two to three miles distance to the fault zone.

Vertical communication throughout the entire Fall River formation is indicated by the delayed response at the upper Fall River observation well (32-9C). Within the Fall River formation, the 11 minute delay in response at the upper observation well is attributed to lateral and vertical anisotropy due to the shale interbeds seen on the conceptual stratigraphic cross-sections for the pump test site (see Drawings 4.1 and 4.2 in Knight Piésold, 2008c). The extent and continuity of

the shale interbeds are not known. Whether the shale interbeds in the Fall River aquifer are sufficiently thick and continuous to serve as vertical confinement for ISL operations will need to be evaluated by analyzing cores from borings as well fields are drilled and by pump tests of individual well field units.

Leakage from a confining layer, presumably the Fuson member, was observed in the 1982 TVA test of the Lakota formation. However, the leakage was observed only relatively late in the TVA tests, at 3,000 to 10,000 minutes, with a much greater pumping rate (495 gpm) and radius of influence. The large-scale vertical hydraulic conductivity value of 2×10^{-4} ft/day (7.1×10^{-8} cm/sec) determined in the 1982 TVA regional test at Dewey using the Neuman-Witherspoon ratio method is sufficiently impermeable to be considered a confining unit.

Hydraulic communication through the Fuson member between the Fall River and underlying Lakota aquifers is not indicated by the 2008 response at observation well 32-10. The 2008 test demonstrates that vertical leakage through the Fuson may not occur over a mile-wide radius. As described in Section 4.1, the Lakota and Fall River aquifers at the Dewey test site appear to be locally hydraulically isolated by the intervening Fuson member with nearly 40-foot head difference. The laboratory core data indicate a very low vertical permeability of 6.2×10^{-9} cm/sec (1.8×10^{-5} ft/day) for the shale sample from within the Fuson shale member.

The laboratory core data for the shale sample from the Skull Creek formation, overlying the Fall River formation, indicate a very low vertical permeability of 5.4×10^{-9} cm/sec (1.5×10^{-5} ft/day), also appropriate for a confining unit.

For the Fall River sandstone, the laboratory core data indicate a horizontal hydraulic conductivity of 6.1 ft/day, and interpretation of the test results calculates that horizontal permeability may be as great as 17 ft/day throughout one of the ore zones. Within the lower Fall River formation, the test results indicate transmissive, rapid response (two to three minutes) between pumping and observation wells up to 467 feet apart with nearly 10 feet of drawdown. Response was nearly 9 feet of drawdown at 1,400-foot distance. This indicates the aquifer was stressed to produce good quality analytical results.

The 2008 test indicates that the lower and upper sandstone portions of the Fall River formation behave as a single, confined, aquifer; vertical confinement for ISL operations will need to be evaluated further to determine the extent of the anistropic properties observed within the Fall

River formation. Hydraulic conductivity values and results from testing in 2008 indicate the Lakota and Fall River aquifers to be locally hydraulically isolated by the intervening Fuson member and the core data indicate very low permeability within the Skull Creek formation. In summary, tests within the Dewey site seem to indicate adequate confinement within the area of interest for the most part, yet further investigation and evaluation into the vertical confinement must be performed on a well field basis.

9.0 Attachment J - Stimulation Program

A stimulation program is not currently being proposed for the PA injection wells.

Well development (described in M - Construction Details), which will include swabbing, will be used to improve well yield by enhancing hydraulic pressure between the undisturbed aquifer and the well and by reducing well bore damage by use of improved well completion techniques.

10.0 Attachment K - Injection Process

The following attachment details the proposed injection procedures to be used at the PA.

The well field will consist of either 5-spot or 7-spot patterns or other regular geometric shapes. A typical 5-spot pattern contains four injection wells at the corners of a square and one production well in the center. The well fields will be based on 70x70-foot or 100x100-foot grids where injection wells will be spaced 70 or 100 feet apart depending on the chosen grid. The wells will be completed so that they can be used as either injection or production wells. The production well will be equidistant from all injection wells serving that production well and equidistant from each other.

Barren lixiviant will be injected into the injection wells and pregnant lixiviant will be recovered through the production wells. A cone of depression in the well field will be maintained by recovering a greater volume of solution than is injected. The cone of depression will help to control the movement of lixiviant away from the well field. The bleed will be approximately 1 percent of the total well field production rate but may be up to 3 percent. The bleed will be disposed of using evaporation ponds and land application, or deep disposal well, or a combination of both. The bleed will be treated to remove uranium and radium to acceptable levels.

Oxygen will be added to the barren lixiviant prior to injection. The oxygen will be fed into the barren lixiviant header via a common connection or through the individual injection well pipes. Solenoids will automatically shut off the oxygen supply during power failure to reduce the risk of oxygen leaks in the lixiviant injection piping.

Carbon dioxide will be added to the barren lixiviant under pressure downstream of the ion exchange resin vessels and the barren solution injection pumps.

The monitoring program is described in Attachment P - Monitoring Program. The manifolds will be visually inspected once a day. Meters and control valves will be installed in the individual well lines to monitor flow rates and pressures. The individual well flows and pressures will be monitored and adjusted daily. Flow meters will also be installed on the main pipelines entering and exiting each header house and monitored continuously. The pipeline pressures will be monitored continuously for indications of spills and leaks. The wellheads will be visually inspected once a month. As groundwater is re-circulated via the ISL process, subsidence (near

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

11.0 Attachment M - Construction Details

The following attachment details the construction procedures that will be utilized for injection, production and monitoring wells at the PA.

11.1 Well Construction Materials

Well casing material will typically be thermoplastic such as polyvinyl chloride (PVC) with SDR 17 wall thickness and 5-inch inside diameter which meets or exceeds the ASTM Standard F480-90e and the NSF Standard 14 (1990). In order to provide an adequate annular seal, the drill hole diameter will be at least two inches greater in nominal diameter than the outside diameter of the well casing. This minimum distance between the drill hole and the well casing will also be maintained if alternative casing diameters are utilized. `Drill cuttings will be returned to mud pits as TENORM.

The annular seal will be pressure-grouted and sealed with either neat cement grout or bentonite grout. Cement grout will be composed of high sulfate resistant Portland cement using adequate cement to yield a slurry weight of approximately 11 pounds per gallon. Water used to make the cement grout will not contain oil or other organic material. Cement grout could contain adequate bentonite to maintain the cement in suspension in accordance with Halliburton cement tables. Bentonite grout will be composed of commercially manufactured sodium bentonite material specifically formulated for well casings. Bentonite grout will be mixed according to manufacturer's recommendations and will contain a minimum of 20 percent solids by weight and have a minimum slurry density of 9.4 pounds per gallon.

Casing will be joined by fittings or using methods recommended by the casing manufacture. PVC casing joints approximately 20 feet apart will be connected with glue or bonded with PVC cement and self-tapping screws, or will be joined mechanically (with pipe threads or a water tight o-ring seal with a high strength nylon spline) to ensure watertight joints above the perforations or screens. Casings and annular material will be maintained throughout the operating life of the wells.

11.2 Well Completion

Typical well completion schematics for injection, production and monitor wells are shown on Figures 11.1, 11.2 and 11.3, respectively.

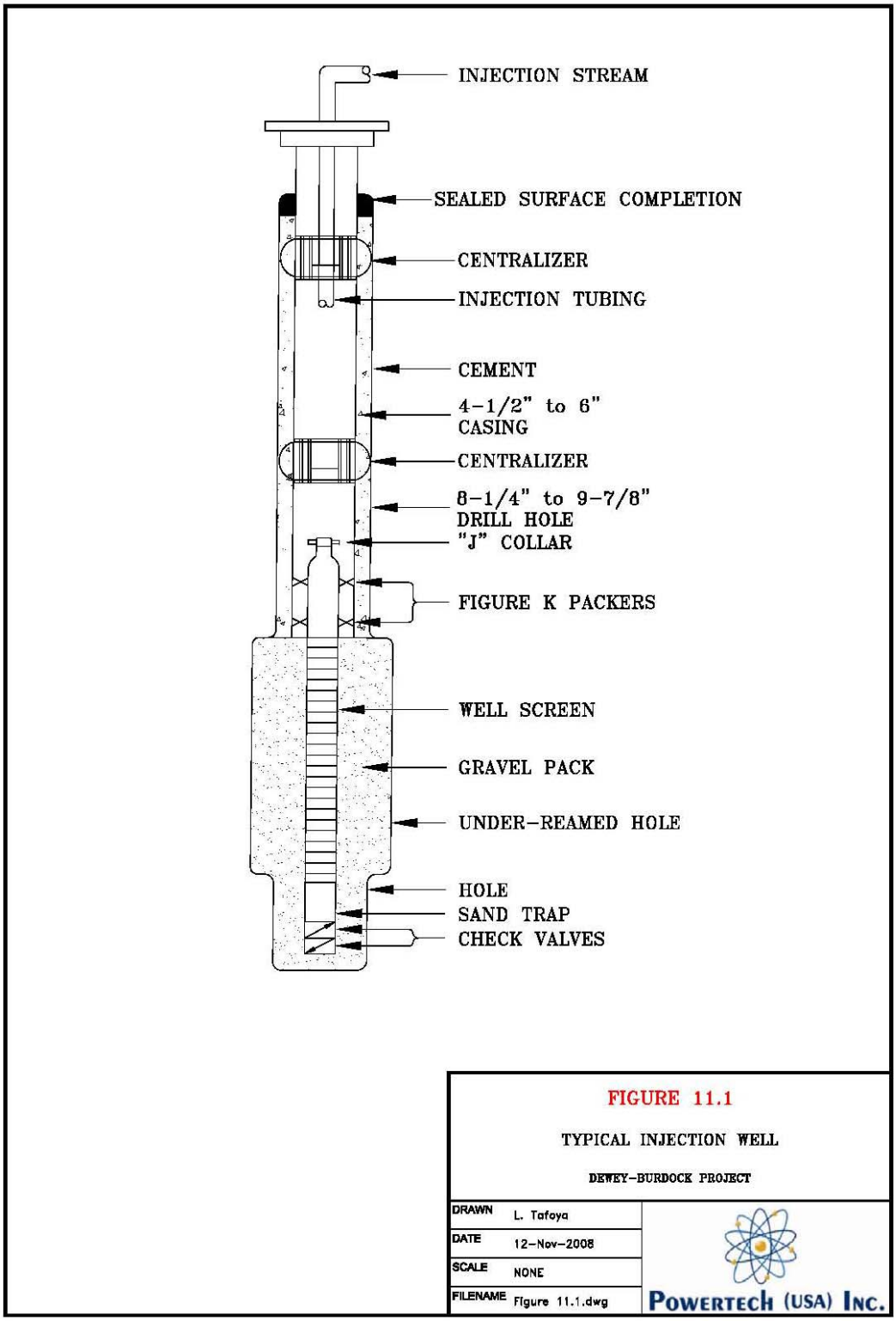

Figure 11.1: Typical Injection Well

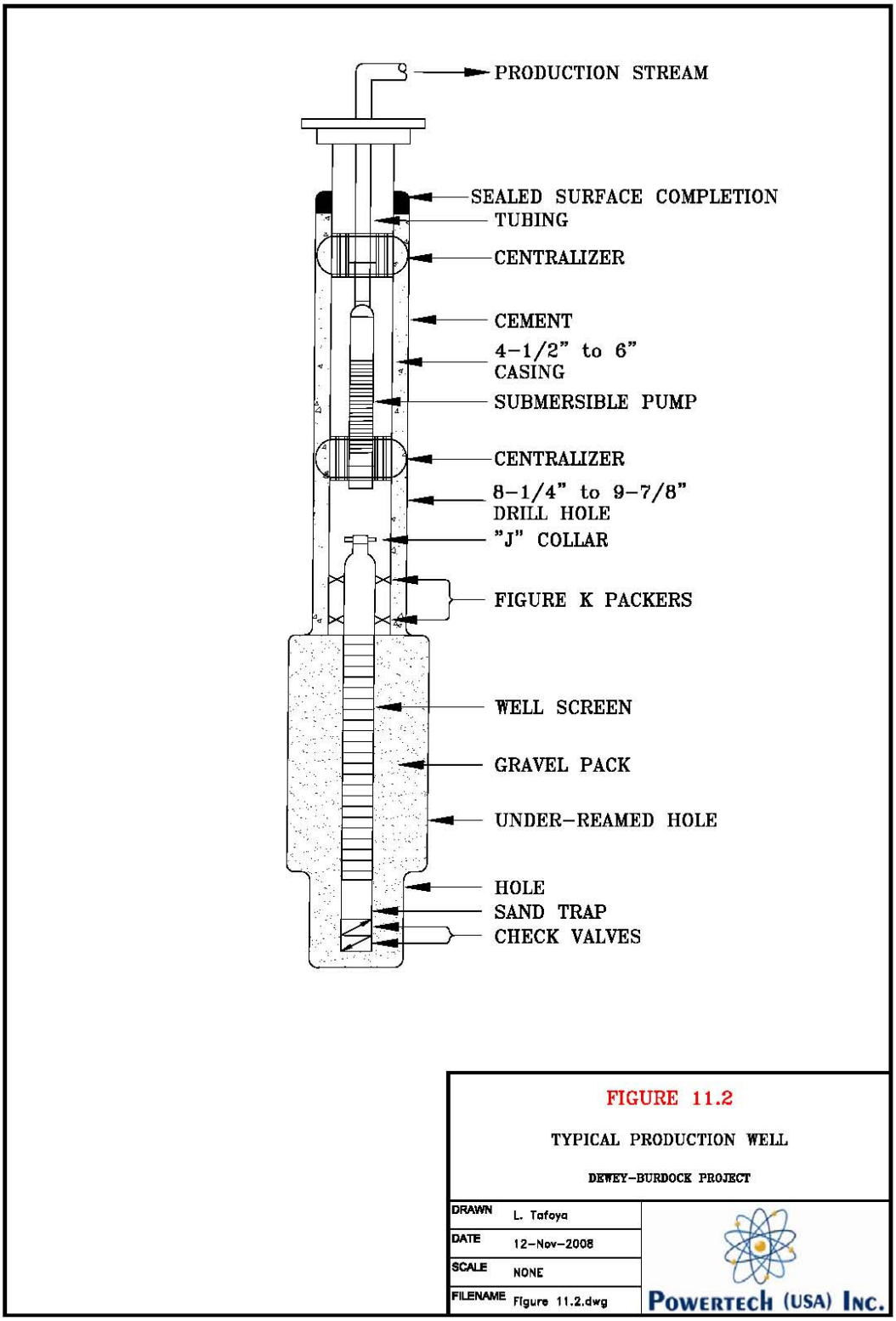

Figure 11.2: Typical Production Well

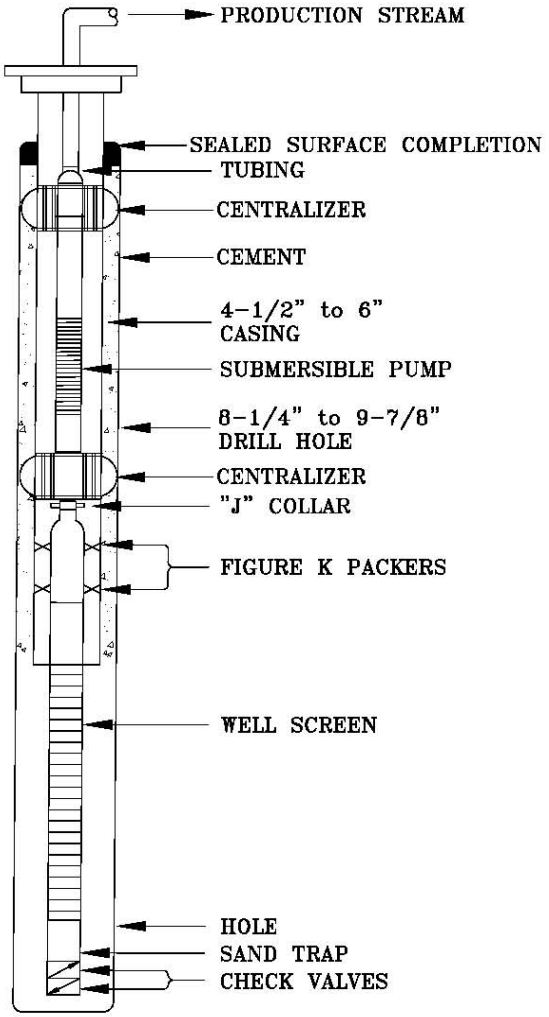

FIGURE 11.3

TYPICAL MONITOR WELL

DEWEY-BURDOCK PROJECT

DRAWN	L. Tafoya
DATE	12-Nov-2008
SCALE	NONE
FILENAME	Figure 11.3.dwg

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Figure 11.3: Typical Monitor Well

Injection, production and monitoring wells will be drilled to the bottom of the target completion interval with a truck mounted rotary drilling unit using bentonite or polymer drilling mud with pH adjusted water and mixed to control the viscosity as recommended by the drilling supervisor. Each hole will be logged, reamed and the casing will be set and cemented to isolate the completion interval from all other aquifers. Drill holes will be large enough in diameter to provide at least two inches of annular space. Cement or other approved sealing materials will be used to stabilize and strengthen the casing and the annulus of the well so as to prevent vertical migration of solutions to unauthorized zones. Effective sealing materials will consist of cement grout or bentonite clay mixtures as described in Section 11.1-Well Construction Materials above. Cement will be placed by pumping it down the casing and displacing the cement with water forcing the cement out the bottom of the casing and back up the casing drill hole annulus. The cementing material will be circulated up the annulus, until return of uncut cementing agent is visible at the surface. The volume of cement used in each well will be determined by estimating the volume required to fill the annulus and ensure cement returns to the surface. However, drilling could result in a larger annulus volume than anticipated and cement may not return all the way to the surface. In these cases the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. With experience at the location the per cent excess cement to ensure returns to the surface can be closely estimated.

After the well is cemented to the surface and the cement has set, the well will be drilled out and completed either as an open hole or it will be fitted with a screen assembly (screen liner), which may have a gravel pack installed between the screen and the under-reamed formation as shown on the well completion schematics (see Figures 11.1, 11.2 and 11.3). The well will then be air lifted or another accepted development technique will be used to remove any remaining drilling mud and/or cuttings until well fluids are clear. A submersible pump may be run in the well for final clean-up and sampling. If sand production or hole stability problems are anticipated, a slotted liner, wire wrapped screen or similar device may be installed across the completion interval to minimize the problem.

A well completion report will be completed for each well. These reports will be made available for review by to the EPA.

11.3 Additional Construction Requirements

Ore grade Gamma log, self potential and single point resistivity electric logs will be run in the pilot holes which will be drilled prior to reaming the hole to final diameter to run casing. These logs will determine the location and grade of uranium and the sand and clay units' depths to properly plan each pattern.

11.4 Well Development

The primary goals of well development are to allow formation water to enter the well screen and flush out drilling mud, or cement filtrate water and to develop the well bore to remove the finer clays and silts to reduce the pressure drop between the formation and the well screen. This process is necessary to allow representative samples of groundwater to be collected, if applicable, and to ensure efficient injection and recovery operations. Wells will be developed immediately after construction using air lifting, swabbing, pumping or other accepted development techniques which will remove water and drilling fluids from the casing and borehole walls along the screened interval. Prior to obtaining baseline samples from monitor or restoration wells, additional well development will be conducted to ensure that representative formation water is sampled. The water will be pumped sufficiently to show stabilization of pH and conductivity values prior to sampling and used to indicate that development activities have been effective.

11.5 Mechanical Integrity Testing

A mechanical integrity test (MIT) of the well casing will be conducted to determine if any significant leaks in the casing and tubing exist following the completion of each injection, production or monitor well, and before they are placed into operation. At least once every five (5) years during the life of each well, a demonstration of mechanical integrity will be conducted. In addition, a MIT will be conducted on a well prior to plugging and abandonment (see Attachment Q - Plugging and Abandonment Plan).

The bottom of the casing adjacent to or below the confining layer above the production zone will be sealed with a plug, downhole packer, or other suitable device. The top of the casing will then be sealed in a similar manner or with a threaded cap, and a pressure gauge will be installed to monitor the pressure inside the casing. Internal casing pressure will be increased to 125 percent of the maximum operating pressure of the well field, 125 percent of the maximum operating pressure rating of the well casing (which is always less that the maximum pressure rating of the pipe), or 90 percent of the formation fracture pressure (which equates to approximately 1 psi per

foot of overburden above the bottom of casing), whichever is less. A well must maintain 90 percent of this pressure for a minimum of 10 minutes to pass the test.

If there are obvious leaks, or the pressure drops by more than 10 percent during the 10 minute period, the seals and fittings on the packer system will be checked and/or reset and another test will be conducted. If the pressure drops less than 10 percent, the well casing will have demonstrated acceptable mechanical integrity.

11.5.1 Loss of Mechanical Integrity

Failure of a well casing to meet the MIT criteria will result in the casing being repaired and re-tested. A well will be used for its intended purpose provided it passes the MIT. A well defect occurring at depth may result in the well being plugged back and recompleted for use in a shallower zone provided it passes the MIT. A well that cannot pass the MIT after repairs will be plugged and abandoned in the manner discussed in Attachment Q - Plugging and Abandonment Plan.

11.5.2 Injection Pressure Limitation

During well field operations, pressure at the injection well heads will not exceed the maximum MIT pressure. Injection wells will only be used for injection purposes if they demonstrate mechanical integrity. Injection pressure at the wellhead will be calculated to ensure that the pressure in the production zone does not initiate new fractures or propagate existing fractures (see Section 8.1, Attachment I). Accordingly, maximum injection pressures will be approximately 125 psi at the header houses located in deeper ore areas. Notwithstanding this restriction, the maximum injection operating wellhead pressures shall not exceed 90 percent of the production zone fracture pressure calculated or 95 percent of the American Society for Testing Materials (ASTM) maximum recommended operating pressure at 75 degrees Fahrenheit for the well casing, whichever is lesser.

According to the EPA Maximum Injection Pressure (MIP) is defined as: The term "maximum injection pressure" generally refers to the maximum permitted injection pressure, that is, the maximum value of injection pressure at which an operator can inject into an injection well. This value is set in the injection well permit. Title 40 of the Code of Federal Regulations (40 CFR) Section 146.13(a)(1) requires that the MIP in Class I and Class III wells be set so as to assure that, except during stimulation, "the pressure in the injection zone during injection does not

initiate new fractures or propagate existing fractures in the injection zone. In no case shall injection pressure initiate fractures in the confining zone ...."

11.5.3 Subsequent Mechanical Integrity Testing

In addition to the initial testing after well construction, a MIT will be conducted on wells after any repair where a downhole drill bit or under-reaming tool is used. Injection wells that exhibit potential subsurface damage will pass a new MIT prior to being returned to service. All wells used for injection of lixiviant, or injection of fluids for restoration operations will be subjected to a MIT at least once every five years.

11.5.4 Reporting

MIT documentation will include the well designation, test date, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting each test. Results of each MIT will be available for inspection by the EPA and SD DENR. MIT results will be reported on a quarterly basis to EPA and SD DENR.

12.0 Attachment N - Changes in Injected Fluid

The following attachment details anticipated changes in pressure, native fluid displacement, and the direction of movement of injection fluid.

A bleed stream will be used to control increase in sulfate and chloride ions and equivalent cations by withdrawing the sulfate and chloride ions at the rate of addition. The withdrawal will increase with the concentration to come in balance with the generation of the ions. Well field formation water from the mining zone will be the source of the injection fluid, so fluid displacement will be minimal. The bleed stream will create a small (1-3 percent) flow of surrounding groundwater into the mining zone.

13.0 Attachment O - Plans for Well Failures

The following section outlines contingency plans to cope with all system shut-ins or failures so as to prevent migration of fluids into any USDWs.

13.1 Introduction

The endangerment of USDWs may occur via any combination of at least six contamination pathways in which fluids can escape the injection zone and enter USDWs (USEPA, 2002a). These pathways include:

- Migration of fluids through a faulty injection well casing
- Migration of fluids upward through the annulus located between a well casing and the drilled hole
- Migration of fluids from an injection horizon through the confining zone
- Vertical migration of fluids through improperly abandoned or constructed wells
- Lateral migration of fluids from the injection zone beyond the exempted area into a USDW
- Direct injection of fluids into or above a USDW

The extent to which a USDW is threatened will depend on a number of factors including:

- The nature of the fluids being injected
- The volume of the fluid being injected
- The effectiveness of the well field monitoring program
- The amount of fluid that may enter the USDW via one or more of the pathways

Proper construction of PA wells as outlined in Attachment M - Construction Details will reduce the likelihood that any USDWs will be threatened.

13.2 Prevention Measures

13.2.1 Integrity Testing of Casing

Each new injection, production and monitoring well will be pressure tested to confirm the integrity of the casing prior to being used for ISL operations. Mechanical integrity is

demonstrated after a well is constructed and before it is put into use. The casing adjacent to or below the confining layer above the injection zone is sealed with a suitable device such as a plug, or downhole packer. The top of the casing is sealed and a pressure monitoring gauge is installed to measure pressure inside the casing. Pressure is increased to 125 percent of the maximum operating pressure rating of the well casing (which is always less that the maximum pressure rating of the pipe), or 90 percent of the formation fracture pressure (which equates to approximately 1 psi per foot of overburden above the bottom of casing), whichever is less and all fittings are checked for leaks. Upon stabilization of pressure, readings are recorded at two-minute intervals for ten minutes. A well passes the test if it holds 90 percent of the original pressure for ten minutes. Wells that fail the pressure test will be repaired or plugged and abandoned and replaced as necessary.

13.2.2 Integrity Testing of Wells

All three types of wells (injection, production and monitoring) must demonstrate mechanical integrity before being put into service. Mechanical integrity will be documented by including the well designation, date and duration of the test, beginning and ending pressures, and the signature of the individual responsible for conducting the test. The results of integrity testing of wells will be maintained onsite and available for inspection by the appropriate regulatory agency.

13.2.3 Shutdown

13.2.3.1 General

Well fields consist of production wells, injection wells, and monitor wells. These wells either pump water from a section of the ore-bearing formation or inject and return water into a section of the ore-bearing formation or monitor for excursion of leach fluids outside the well field. These wells are constructed of well casing that is cemented on the exterior to prevent vertical migration of the leach fluid up the annulus between the outside hole diameter and the casing. Each of these wells are piped into a collection header inside a header house.

A production well will have a circuit breaker in the header house associated with a submersible pump installed in the well that will be labeled by its production well number (e.g. P-100). Each breaker has a start and stop switch that can be used to energize or de-energize the pump motor. The circuit breaker is the main source of electrical power and can be used to de-energize and lock out the pump motor.

Each metered injection well will have a block valve between the header and the meter so that the injection well maybe blocked off to service the meter and the well. There will be a manual flow control valve and a flow meter on each production and injection well to regulate the flow to and from each well and to balance the individual well patterns. The flow meters will be labeled with a designated well identification number. The block valves will be closed for the appropriate injection or production well for shutdown and tag out.

13.2.3.2 Emergency Shutdown

External and internal shutdown controls will be installed in the header houses for operator safety and spill control. The external shutdown will consist of a shutdown switch and an internal shutdown control will be located within the header house sump. The external and internal shutdown controls are designed for automatic and remote shut down of the header house power. Some header houses may have a disconnect at the transformer pole which will, when activated, shut down all electrical power to the header house. The result of this method is to shutdown all electrical power to the header house and mitigate potential electrical hazards while de-energizing the operating equipment including the production sumps.

The sump will also be designed with an automatic shutdown switch. If water level approaches the full level, the switch will cause immediate shutdown of the production well pumps. This will prevent leaks from production wells. A flashing alarm light will activate outside the building to indicate the sump shut-down switch has tripped.

13.3 Excursion Control

During operations, lixiviant is pushed into the ore-bearing formation through the injection wells and is withdrawn by the submersible pumps in the recovery/production wells. Recovering more groundwater than is injected, allows for a localized cone of depression to be maintained for each individual well field. This induced gradient in groundwater movement from the surrounding area toward the well field serves as a control over lixiviant movement and minimizes the potential for excursions of leach fluids to the monitor well ring.

Pre-operational excursion preventative measures include, but are not limited to:

3. Proper well construction and mechanical integrity testing of each well before use

4. Monitoring well design schema for production and non-production monitoring wells based upon detailed borehole or core logging

5. Pre-operational pump test with monitoring system in place to determine detailed understanding of local hydrogeology and to demonstrate the suitability of the monitoring system

Operational excursion preventative measures include, but are not limited to:

1. Regular monitoring of flow and pressure on each production and injection well

2. Regular flow balancing and adjustment of all production and injection flows appropriate for each production pattern

3. Operation of bleed, and continuous measurement of bleed rate

4. Monitoring of hydrostatic water levels in all monitor wells to maintain cone of depression

5. Regular collection of samples from all monitors to determine presence of any indicators of lixiviant travel

Monitoring wells will be set up around the well field for detection of any mining solutions that may potentially migrate away from the mining zone due to an imbalance in well field pressure. The monitoring well detection system is a proven method historically among ISL operations. Powertech proposes to locate a ring of monitoring wells no farther than 400 feet from the well field. The angle between adjacent monitor wells and the nearest injection well in the enclosed well field will be no greater than 70 degrees or 400 feet (closer if necessary to maintain the 70 degree angle) between adjacent monitor wells to prevent an excursion from moving out of the monitor well ring undetected. These monitoring wells will be screened in the same zone as the production well. Prior to injecting chemicals into the well field, a pump test will be conducted showing that the exterior monitor wells are connected to the mining zone and this data will be provided to demonstrate the effectiveness of the monitor well ring prior to injecting chemicals within the monitor well ring. There will be additional overlying monitoring wells within aquifers above the ore-bearing aquifer. The pump test conducted prior to injection of chemicals into the well field will demonstrate that the overlying monitor wells are not connected to the mine zone wells demonstrating confinement. Sampling of monitoring wells will occur on a bi-weekly basis. The monitoring system and operational procedures have proven effective in early detection of mining fluids for a number of reasons:

- Regular sampling for indicator parameters (such as chloride) that are highly mobile can detect lixiviant at low levels well before excursion is created.
- Hydrostatic water levels from production monitor ring provide immediate monitoring of the cone of depression, draw rapid attention, and provide ability for measurement and implementation of corrective response.
- Bleed and cone depression always create flow of native groundwater inward to the mining area.
- The natural groundwater gradient and slow rate of natural groundwater flow is less significant relative to mining activities and gradient caused by the well field bleed.
- Fluids within the well field do not typically have the natural tendency to travel outward.

The combination of these parameters provide minimal chance for the occurrence of non-detection of any excursions.

Effluent controls for preventing migration of mining solutions to overlying and underlying aquifers consist of:

- Regular monitoring of hydrostatic water levels and sampling for analysis of indicator species
- Routine mechanical integrity test of all wells on regular basis (every 5 years) to reduce any possibility of casing leakage
- Completion of mechanical integrity test on all wells before putting into service or after work which involves drilling equipment inside of the casing
- Proper plugging and abandonment of all wells which do not pass mechanical integrity testing, that become unnecessary for use
- Proper plugging and abandonment of exploration holes

Sampling the monitoring wells located within the overlying and underlying aquifers on a frequent schedule.

These controls work together to prevent and detect production fluid migration. Plugging exploration holes prevents connection of the ore-bearing aquifer to overlying and underlying aquifers. The EPA UIC requirement of MITs assures proper well construction and is the first line of defence for maintaining appropriate pressure without leakage. Sampling the monitor wells

will enable early detection of any production solutions should an excursion occur. Additional preventative measures are included in Attachment P Section Number 14.0 Monitoring Program.

Powertech will place a well on excursion status after two or more of the excursion indicators exceed their respective upper control limits (UCLs). After analytical results from a verifying sample has confirmed exceedances, Powertech will identify, and implement as necessary proper reporting, monitoring and response measures that will be taken to:

- recover the excursion into the well field
- remove the well from excursion status

Most wells placed on excursion status were restored below their designated UCLs within 1 to 6 months (NUREG-1910, 2008). The specific indicator species will be determined during well field baseline assessment.

Powertech proposes the following species and parameters be used as indicators to monitor lixiviant travel and excursion control: Uranium, Chloride, Sulfate, Total Dissolved Solids. It is recommended that these be set as a function of the difference between baseline water quality outside of the ore bearing zone and anticipated lixiviant concentrations.

An NRC-sponsored study conducted by Pacific Northwest Laboratory (PNL) presented significant evidence concerning the best way for operators to determine indicator constituents for detection of excursions. According to the PNL study the best indicators of an excursion of process fluids are determined by site specific analysis of typical concentrations of groundwater surrounding the ore-zone (NUREG/CR-3136, 1983). After typical baseline of a well field has been established the lixiviant solution should be considered and constituent types such as dissolved major anions within the lixiviant that are not significantly susceptible to ion exchange, for example, chloride and sulfate would serve as good indicator constituents (NUREG/CR-3136, 1983).

If an excursion was verified through confirmatory sampling and analyses of the designated indicators, the operator will immediately notify proper authorities and implement excursion controls and increase the monitoring efforts in order to monitor the progress of excursion control procedures.

The PA is subject to permit and license requirements from three federal agencies, EPA, BLM and NRC, and a state agency, SD DENR. All four agencies have requirements and responsibilities regarding monitoring for excursions and the corrective action for any such excursion detected.

For example, the SD DENR requirement for remedial action for excursion (ARSD 74:55:01:53) requires the operator to: 1) verify with additional analyses that an excursion has occurred and, 2) to submit a report and remedial action plan for review and approval. "Following review by the secretary of the SD DENR, the operator shall use methods judged necessary and prudent to define the extent of the excursion and to clean up recovery fluids in an expeditious manner" (ARSD 74:55:01:53). Considering that there are four regulatory agencies that are involved in this process, Powertech proposes to develop a single, coordinated procedure with all four agencies during the permitting and licensing process.

13.4 Well Casing Failure

In the event that well failure occurs, the potential for environmental impacts will depend on the type of well (e.g., injection, production, monitoring). With proper casing, cementing, and testing procedures, the probability of such a failure is very low.

Following the identification of a leak in an injection well casing, the well will be examined to verify that well casing failure is the cause of the leak. If possible, a MIT will be conducted. A resistivity log or a video log will be obtained if it will prove useful for identifying the location of the leak. Finally, the well will be plugged and abandoned as detailed in Attachment Q - Plugging and Abandonment.

It is improbable that failure of a production well casing will result in contamination of a USDW because the production well operates by pumping the water from the submersible pump to the surface through tubing. As a result, annulus between the casing and the tubing operates below formation pressure, and there is not a hydraulic gradient for flow out of the casing. Any potential failure would likely result in water entering the well casing due to the pressure in the production well being lower than the pressure in the underlying or overlying aquifers.

Following identification of a defective well casing, the well will be repaired as described in Attachment C - Corrective Action Plan and Well Data or plugged and abandoned as described in Attachment Q - Plugging and Abandonment Plan. The mechanical integrity of all well casings

will be tested prior to use and after any repair that involves entering the wells with a cutting tool such as a drill bit or under-reamer.

The monitoring program described in Attachment P - Monitoring Program will be used to protect USDWs in the event that well casings fail. Monitoring wells, completed into the aquifers above and below the mining zone, will be routinely sampled to check fluid levels and changes in water quality as indicated by changes to the Upper Control limits on the excursion detection parameters of uranium, chloride and sulfate. Should a vertical excursion be detected, surveillance of the well condition by using a camera, a sonic log, electric log or mechanical integrity testing would be conducted. If the well is determined to be damaged beyond repair, the well would be replaced with a new well. If the excursion well is an injection well (which is more likely to have an excursion associated with it instead of an extraction/production well) the well would be packed off at the bottom, a pump would run down the hole and the use would change from an injection to an extraction well and the excursion would be pulled back into the proper zone.

For horizontal excursions, surveillance of the well condition will also be determined and the well replaced if damaged beyond repair. Well field flow rates will be adjusted to pull the excursion that is detected back to the well field until the indicator parameters (i.e., chloride, sulfate and uranium) are reduced to acceptable levels. If the flow adjustment fails to correct the excursion, wells will be drilled and pumped inside the monitor well ring adjacent to the well that is on excursion to pull back the excursion inside the monitor well ring.

13.4.1 Historic Exploration Drill Holes

In general, historic exploration drill holes are believed to have been abandoned using either abandonment mud, drilling mud or a combination of bentonite and drilling mud. These materials are likely to have provided an effective seal against fluid communication between aquifers penetrated by exploration drill holes. Also, the presence of native clays and their potential for swelling can act as a natural mechanism for plugging holes. However, some drill holes may not have been properly abandoned. If inadequately abandoned wells are identified during well field pumping tests, Powertech will require plugging and abandonment to be conducted as detailed in the South Dakota plugging standards (ARSD 74:11:08).

13.5 Operational Pumping Tests

Prior to start-up of a well field, pumping tests will be conducted to demonstrate that communication between the production zone and the underlying or overlying aquifers is not taking place. If pump test results indicate that leakage between aquifers has occurred due to a well casing failure, the source of the leakage will be located, re-entered, plugged and abandoned as described in Attachment Q - Plugging and Abandonment. If the leakage is the result of improperly plugged and abandoned drill holes, the holes will be located, re-entered, plugged and abandoned following South Dakota plugging standards.

13.6 Holding Ponds

Powertech proposes two methods for disposal of all well field generated wastewater at the Dewey Burdock project. These include:

1. Deep well injection
2. Land application with pre-treatment ion exchange and co-precipitation of radium

For both applications holding ponds will be required. The design criterion for both systems is such that it would allow continuous disposal of 3 percent bleed as well as simultaneous operation of restoration activities.

In the case of land application, storage will be required for non-growing seasons such that the total pond capacity required will be significant to allow for storage of these fluids for 8 months of the year. One or more of these ponds will also be used to settle out radium to levels allowable for land application.

In the case of deep disposal injection, ponds will be needed, to a far lesser extent, only for surge and temporary storage. Of these methods, Powertech prefers at this time to use deep well injection, partially due to the smaller holding ponds required.

The ponds have been designed to meet South Dakota Administrative Rule 74:29:11:23, pond and surface impoundment design and construction requirements. The ponds were sized using the SPAW model (Saxton, 2006), which models the daily water budgets of inundated ponds and wetlands, assuming the following inflow to the ponds at each site:

1. An inflow rate, consisting of production bleed and restoration flows, of 320 gpm for 24 hours per day, 365 days per year

2. All irrigation tail water and rainfall runoff from the irrigated (land application) areas is returned to the ponds

With these design conditions, the ponds will occupy 75.31 acres and land application areas (pivot irrigation systems) will occupy 875 acres. Suggest insert information from KP pond design here to illustrate the magnitude of the ponds for the land application option.

The assumed outflow from the ponds at each site is 850 gpm, 24 hours per day, 137 days per year (May 11 to September 24) during irrigation of the land application areas.

Using these assumptions, the ponds are sized to contain a volume with a one percent exceedance probability for the 15-year operating life of the facility.

Should the project operate with only deep disposal well(s) as the method of waste water disposal, a much smaller pond design is required. Sizing of this pond will be estimated upon additional design of the project but is expected to be less than 7.2 acres. Should both land application and deep disposal options be utilized, the total number and size of ponds are expected to fall somewhere between the two options. Installation of deep disposal well(s) is deemed initially feasible due to characterization of the water quality and geologic structure at and surrounding the project area. Further analysis is in progress to determine the location of this well(s) with possibilities within the PAA as well as near the PAA within Wyoming. Powertech expects that the well will be classified under a class V permit if successfully permitted.

The designs of both systems for wastewater disposal have the capacity of 3 percent bleed on a continuous basis for the life of the project. This bleed is believed to be at a minimum two to three times anticipated normal requirements of well field bleed in order to maintain sufficient cone of depression for operational well field control. This design criterion is believed to be highly conservative since it is not expected that the project will reach the full capacity of waste water disposal systems.

14.0 Attachment P – Monitoring Program

This attachment details the proposed monitoring program for the PA.

14.1 Introduction

During the Proposed Action, an extensive groundwater sampling program specific to each well field will be conducted prior to, during, and following ISL operations to identify any potential impacts to water resources of the area. The groundwater monitoring program is designed to: 1) establish baseline water quality prior to mining, 2) detect excursions of lixiviant either horizontally or vertically outside the of the target mineralization zone, 3) demonstrate compliance with groundwater quality standards, and 4) determine when the mined sandstone aquifer has been adequately restored following ISL operations. Objectives 1 (partially) and 4 will be accomplished using injection and recovery wells. Objectives 1 (partially), 2, and 3 will be accomplished using two types of dedicated monitoring wells consisting of perimeter, and internal monitoring wells.

14.2 Monitoring Well Locations and Spacing

The proposed design and placement of monitoring wells, including the production zone monitor ring and overlying and underlying monitor wells, is but one of the safeguards employed to detect and recover a potential breach outside the production zone. Technology has enabled substantial advances in the operational management of monitoring systems that are typically applied to monitoring of in-situ operations. This monitoring program will be implemented in a manner that maximizes and combines the expertise of qualified operators and engineers with proven technologies.

Some features considered in the design of monitoring programs include but are not limited to: hydrostratigraphic units and their lateral and vertical continuity; information on the geometry of the boundaries and boundary conditions; physical form of potential migrating fluid (i.e., dissolved, suspended); structural features of the geology; and chemical properties and potential reactions of groundwater, the aquifer matrix, and lixiviant. Processes that are considered include but are not limited to: steady-state and transient flow conditions; advection, dispersion; sorption, and precipitation. The objective of monitoring is to indicate the presence of lixiviant movement outside the production zone in either a horizontal direction via a production zone monitoring well ring, or in a vertical direction via overlying and underlying groundwater monitoring wells. The monitoring program will be designed based on factors such as groundwater flow direction and

travel time, and continuity and characteristics of hydrostratigraphic units, to strategically place monitor wells around, above and below the production zone to allow prompt detection of possible horizontal and vertical migration of lixiviant or production and restoration related fluids. Well fields of large size and more complex hydrogeology may require a greater number of suitably designed and positioned wells in order to ensure adequate migration detection capability. The design of monitoring well programs must be flexible enough to allow for additional installation of monitoring wells if the primary monitoring effort indicates there is a need to further delineate the horizontal or vertical extent of migration (NRC, NUREG–1757, Vol. 2). Well field monitoring will be designed according to site specific scientific and technical conditions that provide safeguards to humans and the environment. Refer to Plate 7.1 which illustrates the monitoring well layout for a typical well field at the PA.

14.2.1 General Monitoring Procedure

Production zone monitoring wells are installed around the periphery of each production area to monitor for any fluids that might escape the hydraulic controls (Hunkin, G. G., 1977 and Dickinson, K. A., and J. S. Duval, 1977) with a screened interval open to the sand unit containing the production zone. This monitoring "ring" design serves two purposes: 1) to monitor any horizontal migration of fluid within the sand unit or aquifer where production is occurring, 2) to determine baseline water quality data and characterize the area outside the production pattern area. The Operational monitoring program will require periodic sampling and analysis from these wells with respect to site specific parameters (lixiviant indicators) that may be specified within the NRC's Source Materials License. Well field background concentrations will be determined and UCLs will be established for particular constituents indicative of a possible process water excursion. By establishing UCLs, the operator is allowed the capability of early detection of an excursion and then has the time apply corrective action before water quality outside the aquifer exemption boundary is affected (NUREG/CR-6733, 2001). Production zone monitor wells will be located no more than 400 feet from the production area, and will be spaced no more than 400 feet between productions zone monitoring wells. Production zone monitoring wells are installed before the start of production activities in order that required baseline sampling and hydrologic tests (as required) can be conducted.

Non-production monitoring wells consist of two types of monitor wells termed "overlying" and "underlying". The screened intervals of overlying wells are located in the sand unit or aquifer immediately above the ore-bearing stratum. The overlying non-production monitoring wells are designed to provide monitoring of any upward movement of production fluids that may occur

from the production zone and to guard against potential leakage from production and injection well casing into any overlying aquifer. The overlying wells are used to obtain baseline water quality data and are used in the development of UCLs for the overlying zones that will be used to determine if vertical migration of production fluids is occurring. Vertical monitoring is generally set up with a density of wells ranging from one every three or five acres and where confining layers are very thick and permeabilities are negligible, requirements for vertical excursion monitoring can be relaxed or eliminated for underlying aquifers (NUREG/CR-6733, 2001). The screened zone for the overlying wells is determined from electric logs by qualified geologists or hydrogeologists. The first layer of overlying non-production zone monitoring wells will be evenly distributed through the production area with a minimum of one well for every four acres of production area. Should additional aquifers exist above the first monitoring layer; additional overlying monitors will be located in these aquifers with a minimum of one well positioned for every eight acres of production area.

A single layer of underlying monitor wells will be completed in the first sand unit or aquifer underlying the ore-bearing stratum similarly based on the local lithology. The underlying monitor wells are used to obtain baseline water quality data and are used in the development of UCLs for the underlying aquifer that will be used to determine if vertical migration of production fluids is occurring. The screened zone for the underlying monitor wells is determined from electric logs by qualified geologists or hydrogeologists. Underlying non-production monitoring wells will be evenly distributed through the production area with a minimum of one well for every four acres of production area. Underlying wells will not be installed below the Lakota formation, primarily due to the presence of the approximately 100-foot-thick and relatively impermeable Morrison formation immediately below the Lakota formation.

All of the non-production zone monitoring wells will be designed and installed for detection of potential excursions of lixiviant, if such an excursion were to occur. Design of the monitor ring and overlying and underlying monitor wells will be done for each well field according to site specific lithology and processes of the production zone(s) of each well field. Powertech will present each monitoring well program to EPA and the SD DENR before installation of proposed well placement to ensure administrative approval is obtained. After completion of the required hydrologic test, it may be necessary to revise the location and/or number of wells proposed. Each well field will be handled on a case-by-case basis in consultation with the EPA and SD DENR. Powertech's Safety and Environmental Review Panel (SERP) to be established under NRC requirements will review hydrologic test results and documentation to ensure that the monitoring

wells are properly located. Based on current knowledge of site lithology and processes of the production area, and industry proven practices, the number and spacing of overlying and underlying monitoring wells meets criteria to protect human health and the environment. All wells completed in the production zone monitor ring, and overlying and underlying aquifers will be subject to remedial action and reporting requirements pertinent to EPA and SD DENR rules.

14.3 Flow Monitoring

Oxygen is injected into the barren solution in the header house as an oxidant and the oxygen flow rate is metered via an RCM meter (or rotameter on individual injection meter runs) which reads out in Standard Cubic Feet per Minute (SCFM). The meters are calibrated for a given pressure. CO_2 addition is metered by a gas flow meter, which is calibrated for CO_2 at a specific pressure. The calibration and maintenance of all monitoring and recording equipment will occur on a regular basis to ensure that all equipment is in proper working order.

South Dakota UIC Class III rules were promulgated in April 2008. ARSD 74:29:11:32 addresses non-production zone monitoring. The rule provides for alternative non-production zone monitoring well location and spacing to be considered if the operator demonstrates that the proposed location or spacing will adequately provide monitoring coverage. Based on industry experience in locating and spacing overlying monitor wells and the low probability of any upward fluid migration going undetected, along with considerations of local lithology, Powertech believes the proposed locations and spacing are sufficient for the monitoring of any potential upward migration of production fluids. The monitoring program will be designed in an effort to satisfy both Title 40: Protection of Environment PART 146—Underground Injection Control Program: Criteria and Standards and Chapter 74:55:01 Underground Injection Control -- Class III Wells for the state of South Dakota.

14.4 Water Monitoring

Powertech's groundwater monitoring program is designed to establish baseline water quality prior to mining and along with other production zone wells, determine when production zone aquifer has been adequately restored following mining. The water quality sampling and analysis requirements were determined based upon references listed in SDAR 74:54:01:06. The USGS "National Field Manual for the Collection of Water-Quality Data; Techniques of Water-Resources Investigations Book 9" methods employed for cleaning of equipment, collection of water samples, and field measurements. This manual can be found using the reference listed within the Reference section of this document or obtained via the USGS website:

http://water.usgs.gov/owq/FieldManual/. Energy Laboratories Inc. preformed the analysis for baseline characterization. Laboratory Identification Numbers are as follows: main laboratory in Casper, Wyoming has an EPA ID of WY00002; the radiochemistry laboratory in Casper, Wyoming has an EPA ID of WY00937; the laboratory in South Dakota has an EPA ID of SD00012 (see Figure 14.1 for signatures and laboratory verification letter, in accordance with SDAR 74:55:01:26:10).

ENERGY LABORATORIES, INC. • 2821 Plant Street • Rapid City, SD 57702 • www.energylab.com
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March 20, 2009

Cory Foreman
Respec Inc
3824 Jet Dr
Rapid City, SD 57701

Energy Laboratories Inc. was the analytical laboratory that conducted the Dewey Burdock preoperational surface water and groundwater analysis from July 2007 through February 2009. The project was managed out of the Rapid City Branch at 2821 Plant St. in Rapid City, SD. Our Casper Branch at 2393 Salt Creek Hwy in Casper, Wyoming conducted the metal and radiological analysis. All sample runs were accompanied by quality control and quality assurance practices. Rapid City Energy Laboratory EPA code is SD00012. Casper's EPA code is WY00002.

Linda Larson
Linda Larson
Branch Manager
Energy Laboratories Inc
2821 Plant St
Rapid City, SD 57702
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Figure 14.1: Energy Laboratory Identification and Signature Sheet

Monitoring safeguards utilized during operational phase include monitoring production and injection rates and volumes, and wellhead pressures. Monitor well sampling will also be conducted during restoration, including stabilization monitoring at the end of the restoration activities to determine the achievement of acceptable water quality.

14.4.1 Water Monitoring Network

The groundwater monitoring network is comprised of private wells in the vicinity of the proposed permit area, perimeter production zone monitoring wells surrounding the well field, baseline production zone wells within the interior of the well field, and the non-production zone monitor wells within the overlying and underlying aquifers (if deemed appropriate).

Private Wells

All private wells within 0.62 miles (1.0 kilometer) of the well field boundary that Powertech has received landowner authorization to sample will be sampled annually with the initial sampling event occurring prior to mining operations. Analytes for these wells will consist of natural uranium and radium-226.

Perimeter Production Zone Monitoring Wells

Subsequent to delineation of the well field boundary, a ring of production zone monitoring wells will be installed around the perimeter of the well field area. These wells will be designed primarily for the detection of lixiviant excursion from the production area well field. Refer back to Attachment K Section 10.0 for further information on the well design and location.

Baseline Production Zone Wells

Baseline production zone wells will be uniformly distributed across the production area. These wells are utilized for establishment of pre-mining water quality within the production zone. The minimum number of production zone wells to be sampled for baseline analysis within a production area will be five. These wells will be sampled three times each at intervals of two weeks to provide repeatability of the data. They will be sample prior to mining and after restoration of the ground water is complete as demonstration of reclamation.

Non-Production Zone Monitor Wells

Non-production zone monitoring wells will be installed in the overlying and underlying (if deemed necessary) aquifers related to the production zone aquifer. They will be designed to detect migration of lixiviant outside the production zone aquifer. Non-production zone wells will

be located within the production zone pattern. At the minimum, these wells will be completed in the overlying aquifer to the production aquifer. Refer back to Attachment K Section 10.0 for further information on the well design and location.

14.5 Hydrostatic Monitoring

Additional excursion preventative techniques incorporated into Powertech's monitoring program include fluid volume and rate monitoring and wellhead pressure monitoring as described below.

14.5.1 Fluid Volume and Rate

Accurate assessment of water balance for a well field is achieved by monitoring the extraction (production) and injection rates and volumes. A bleed system will be employed that will result in less solution injection than total volume of fluids (native groundwater and lixiviant) extracted. A bleed of at least 0.5 percent will be maintained during production. This 0.5 percent bleed will cause an inflow of groundwater into the production area and prevent the loss of lixiviant solution. The excess solution (bleed) will be pumped to the storage ponds.

14.5.2 Wellhead Pressure

Wellhead pressure will be monitored at all injection wells. Pressure gauges installed at each injection wellhead or on the injection manifold will be monitored at least daily. The maximum injection pressure at the wellhead will not exceed 120 psi, nor will it exceed the manufacturer's recommended pressure for the piping material. Injection rates will be adjusted to maintain wellhead pressure below that level.

Nonproduction zone monitoring wells will be located laterally within the production area. In the first overlying aquifer above the production zone, a minimum of one (1) monitoring well monitoring well will be completed for every one (4) acre of production area. If an additional overlying aquifer is present, a minimum of one (1) well for every four (4) acres of the production area will be completed. In the first underlying aquifer, a minimum of one (1) monitoring well will be completed for every eight (8) acres of production area.

14.6 Water Quality Sampling and Analysis

The sampling frequency and parameters measured are addressed in the following subsections. Water quality sampling will serve as a safeguard to detect excursions of lixiviant outside the

production area during mining operations, and will determine when a production zone aquifer has been acceptably restored following mining.

14.6.1 Groundwater Quality

Powertech will establish the baseline groundwater quality before beginning operations in a well field. Production and monitoring zone wells will be sampled at least four times over a sufficiently spaced interval to indicate well field baseline. Wells will be selected based on a density of one well per 4.0 acres of mine unit, all wells in the monitoring ring, and wells in aquifers above and below the confining layers of the production zone. Wells will be sampled for proposed parameters as shown in Table 14.1.

Based on statistical analysis of the data following ASTM Standard D 6312 (ASTM, 2001) to determine the baseline range of statistical variability of an indicator constituent, target restoration goals (TRG) will be established, which will be used to assess the effectiveness of groundwater restoration activities. Powertech will consult with SD DENR concerning the specific groundwater suite of constituents prior to well field baseline evaluation.

Sampling will follow the appropriate quality assurance/quality control (QA/QC) procedures. Samples will be analyzed by a National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory. Results will be submitted to the EPA and SD DENR on a quarterly basis as described below in Section 14.8 – Reporting.

Subsequent to establishing well field baseline, a groundwater monitoring program will be designed to specifically address each individual well field's lithology, and groundwater chemistry; designated analytes, UCLs will be established and monitored for during operations and TRGs will be established and monitored for during and subsequent to restoration.

Table 14.1: Baseline Water Quality Parameters and Indicators for Groundwater

Test Analyte/Parameter	Units	Method
BULK PROPERTIES		
pH	pH Units	A4500-H B
Total Dissolved Solids (TDS)	mg/L	A1030 E[1], A2540 C
Conductivity	µmhos/cm	A2510B
CATIONS/ANIONS		
Chloride	mg/L	E300.0
Sulfate	mg/L	E300.0
Total Alkalinity (as $CaCO_3$)	mg/L	A2320 B
TRACE METALS		
Arsenic, As	mg/L	E200.8
Iron, Fe	mg/L	E200.7
Lead, Pb	mg/L	E200.8
Manganese, Mn	mg/L	E200.8
Strontium	mg/L	E200.8
Uranium, U	mg/L	E200.8
Vanadium	mg/L	E200.7, E200.8
RADIONUCLIDES		
Gross Alpha=Alpha Particles	pCi/L	E900.0
Gross Beta=Beta Particles and Photons	mRem/Year	E900.0
Radium-226	pCi/L	E903.0
Radon-222	pCi/L	D5072-92

14.7 Excursions

The monitoring program described in Attachment P – Monitoring Program will be used to protect USDWs in the event that well casings fail. Monitoring of wells, completed into the aquifers above and below the mining zone, will occur on a bi-weekly basis to check fluid levels and changes in water quality. During operations, lixiviant will enter the ore-bearing formation through the injection wells and is drawn to the recovery/production wells. Each individual well field within a production zone monitor well ring will produce a localized cone of depression by recovering more groundwater than is injected. This induced gradient in groundwater movement from the surrounding area toward the well field will serve as a control over lixiviant excursions. If an excursion occurs, an increase of the cone of depression to pull back fluid is the first line of defence. If concentrations decline within 60 days after the excursion is verified, no further corrective action will be implemented. Additional measures will be implemented, such as drilling

and pumping of wells inside the monitor well ring near the well that is on excursion to pull back the excursion inside the monitor well ring, if a declining trend does not occur in a reasonable time period, i.e., 60 to 90 days. After a significant declining trend is established, normal operations will resume and be maintained as long as the declining trend continues and concentrations return to acceptable levels. Best Management Practices and Best Practicable Technology will be employed throughout the excursion detection and response phases.

14.7.1 Injection Fluid Characterization

The injection fluid will be sampled monthly. Samples will be collected from or before the wellhead following the appropriate QA/QC procedures. Changes to the injection fluid composition will result in an additional sampling event followed by regular monthly sampling and analysis. Samples will be submitted to an EPA certified commercial laboratory for the analyses detailed above in Section 14.6.1 – Groundwater Quality.

14.8 Reporting

At minimum, the quarterly monitoring reports will include the following information:

- Physical, chemical and other relevant characteristics of injection fluids
- Monthly average, maximum and minimum values for injection pressure, flow rate and volume
- Additional monitoring results as discussed above
- Periodic MIT results
- Any well maintenance activities

Appendix G contains an example of the quarterly monitoring report form (EPA Form 7520-8, Rev. 8-01) required by the EPA.

Signed quarterly reports will be submitted electronically unless otherwise directed by the EPA. If required, a signature letter from the Project Manager will accompany the disk to certify the report. Reports will consist of monthly summary information for the project. Monitoring reports will include raw data and graphical analysis for the current reporting period to date. Each calendar quarter, the maximum, minimum, and average monthly values for each continuously monitored parameter specified for the injection wells will be tabulated. A narrative description of any deviations from permit limitations will be given. Maintenance activities, MITs, or other

significant events that took place during the reporting period will be described. If an excursion is detected by an increase in Upper Control Limits of the excursion detection parameters of uranium, sulfate or chlorides is detected, it will be reported verbally within 24 hours and followed up in written form.

In accordance with South Dakota requirements casing MIT or resistivity logs will be implemented every 5 years.

14.9 Recordkeeping

All monitoring information, including calibration and maintenance records and data from the continuous monitoring instrumentation will be retained for at least 3 years after all wells have been plugged and abandoned.

- Information on the nature, volume, and composition of all injected fluids until three years after all the wells have been plugged and abandoned
- Results of MITs, any other tests required by EPA and/or SD DENR, and any well work-overs completed

The records discussed above (originals or copies) will be retained on site unless written approval to discard the records is provided by the EPA:

Copies of these records (or originals) will be maintained for all observation records throughout the operating life of each well. These records will be made available for inspection at the facility and retained unless written approval to discard the records is provided by the EPA.

15.0 Attachment Q - Plugging and Abandonment Plan

Attachment Q includes the proposed Plugging and Abandonment Plan for the PA. The plan addresses the plugging and abandonment of wells in a manner which will prevent movement of fluids through the well, out of the injection zone either into or between USDWs or to the land surface.

Key topics covered in the proposed Plugging and Abandonment Plan includes the following:

- Method of placement of the plugs
- Procedure used to plug and abandon each well
- Type, number, and placement (including elevation of the top and bottom) of plugs to be used
- Type, grade, and quantity of plugging material to be used
- Information demonstrating that a well within the AOR that underlies or is in an exempted aquifer provides adequate protection of USDWs

15.1 Plugging and Abandonment Plan

Prior to plugging, each well will undergo MIT to demonstrate the integrity of casing and cement that will be left in the ground after closure (see Attachment M - Construction Details, Section 11.5 – Mechanical Integrity Testing). Alternatively, cementing records will be used to show that an adequate quantity of cement is present to prevent upward fluid movement within the borehole outside of the casing. If it cannot be verified that a well casing is grouted properly, an effort will be made to plug the annulus from the bottom of the annulus to the ground surface, using the same materials required for plugging the inside of the casing as described below.

Wells will be opened and debris and downhole equipment such as the tubing and pumps will be removed to prevent obstacles from interfering with plugging operations. The wellhead and casing will be removed to 3 feet below ground surface. A tremie pipe will be used to add grout to wells that are more than 40 feet deep.

Injection, production and monitoring wells that are completed into a confined aquifer or multiple aquifers will be plugged with bentonite grout provided the weight of the bentonite grout column will be sufficient to overcome the bottom hole pressure. If bentonite grout will not be sufficient,

cement grout will be placed from the bottom of the well to within 8 feet of the ground surface. Cement grout will be placed from 8 feet below ground surface to within 3 feet of the ground surface. The top 3 feet of the well will be backfilled with native material and reclaimed. If a tremie pipe cannot be lowered inside the well-casing for grout placement, a tight connection will be made to the top of the casing in order to pump a sufficient volume of cement grout down to fill the well under pressure. Bentonite grout will not be used if the tight connection method is used. Figure 15.1 shows a generalized schematic of a plugged and abandoned well completed into a confined aquifer or multiple aquifers.

Wells completed into an unconfined aquifer where a single aquifer is encountered will be backfilled with clean sand or gravel to the top of the aquifer. Above the aquifer, clay, bentonite grout, or cement grout will be used for plugging to within at least 3 feet of the ground surface. If clay is used as the backfill material, a minimum of 2 feet of dry bentonite, bentonite grout, or cement grout will be placed at the top of the aquifer. The top 3 feet of the casing or hole, if not filled with clay, bentonite grout, or cement grout will be backfilled with native material and reclaimed. Figure 15.2 shows a generalized schematic of a plugged and abandoned well completed into an unconfined aquifer.

Bentonite grout, composed of commercially manufactured sodium bentonite material specifically formulated for well casings, will be mixed according to manufacturer's recommendations and will contain a minimum of 20 percent solids by weight and have a minimum slurry density if 9.4 pounds per gallon. Cement plugs will consist of cement grout prepared in the same manner as used for well construction as described in Section 11.1 – Well Construction Materials. Specifically, cement grout will be composed of Portland cement and mixed with appropriate amounts of bentonite and accelerator in accordance with Halliburton cementing tables to yield a minimum slurry weight of approximately 11 pounds per gallon. Water used to make the cement grout will not contain oil or other organic material.

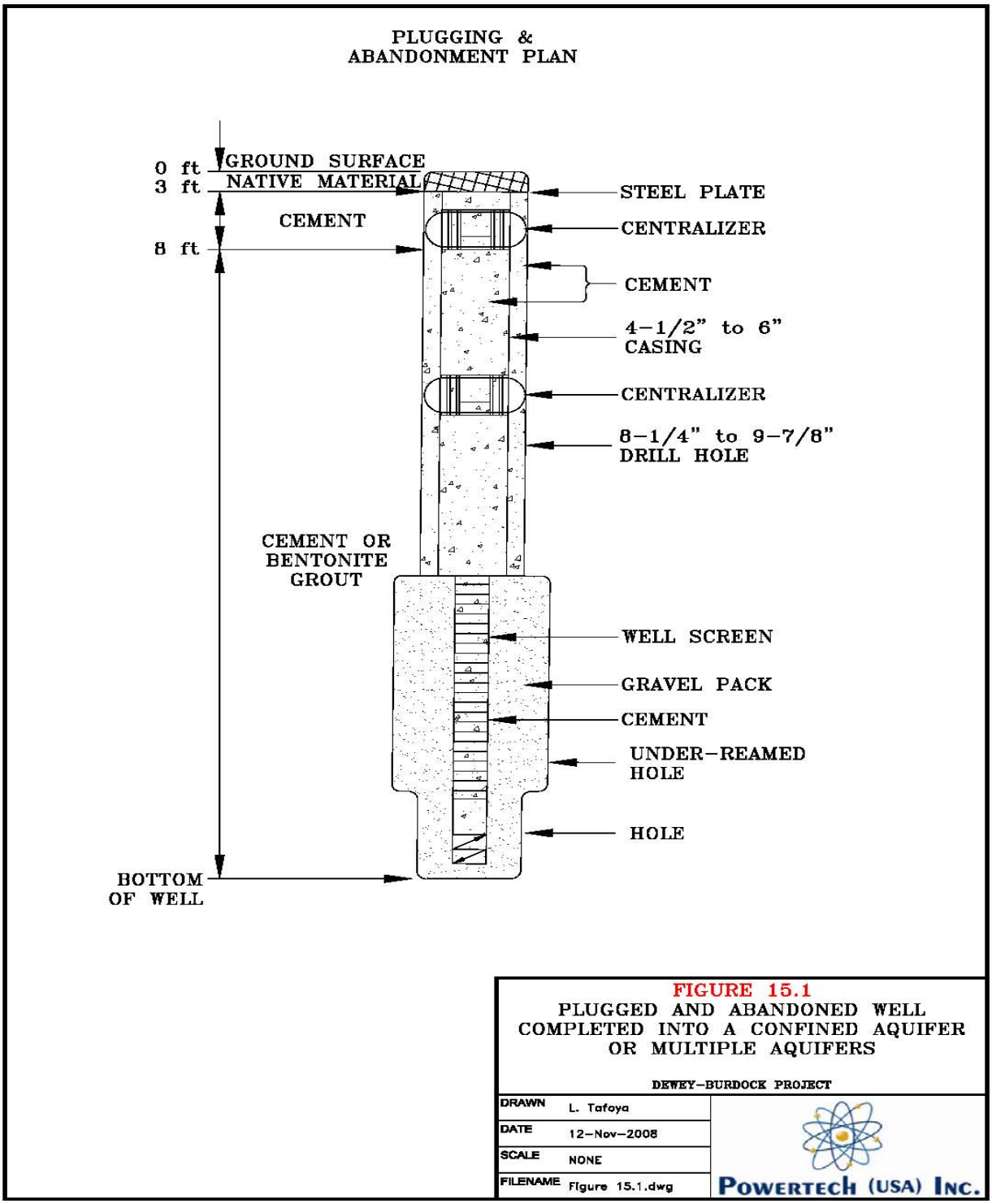


Figure 15.1: Plugged and Abandoned Well Completed into a Confined Aquifer or Multiple Aquifers

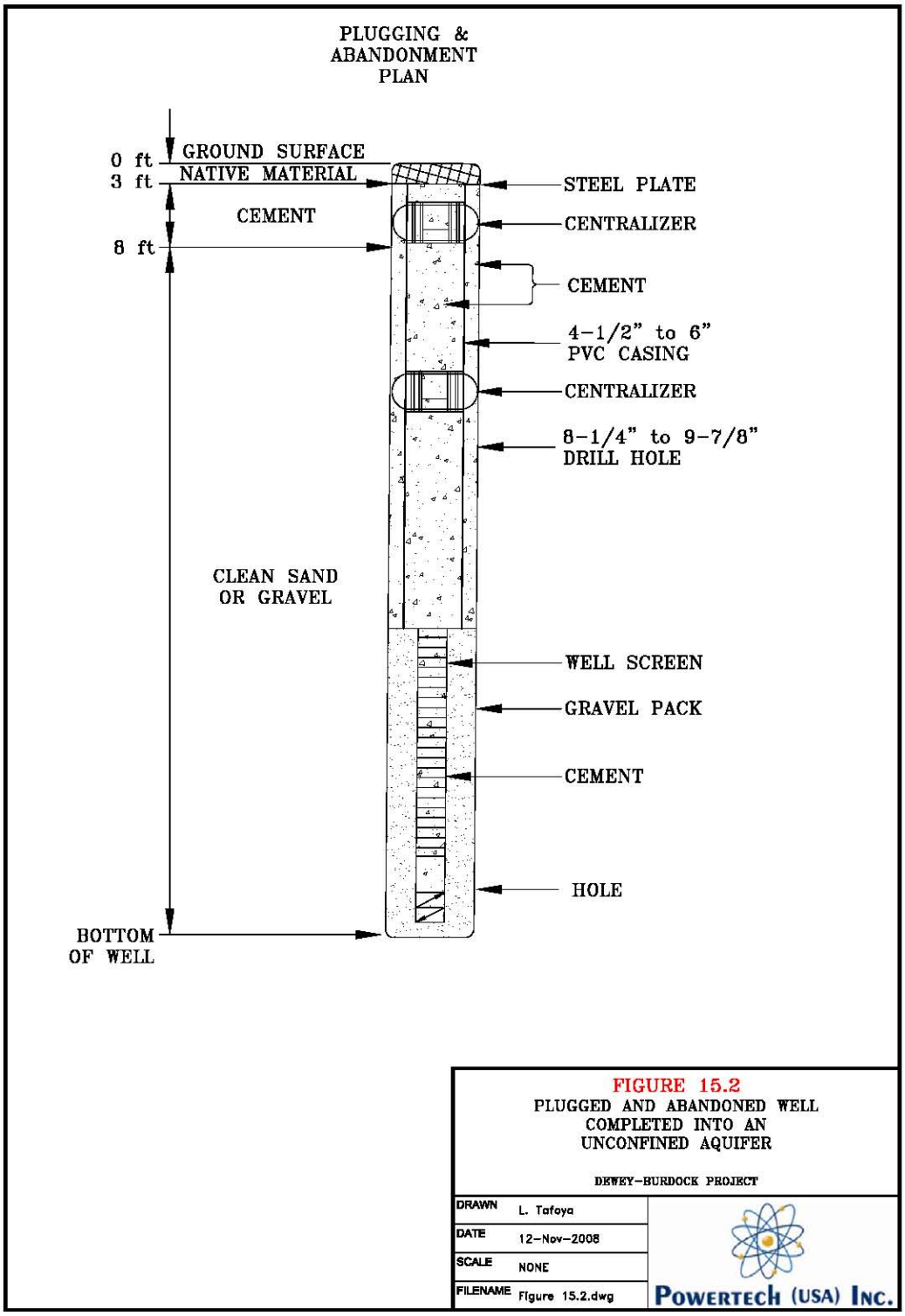


Figure 15.2: Plugged and Abandoned Well Completed into an Unconfined Aquifer

A steel plate will be placed on top of the sealing mixture with the permit number, date of plugging and well identification number clearly displayed. The tag will be affixed to the top of the plug at a minimum depth of 2 feet below ground surface. The locations of the abandoned wells will be identified by recording the boundaries of each well field and the location of the monitor well ring around each well field as a deed notice with the appropriate county.

Wells in which water is not encountered or only low-permeability formations such as clays, shales, or till are encountered will be backfilled with material free of contamination. In order to restore the natural conditions as much as possible, the fill will have a permeability less than or equal to the permeability of the formations encountered. The wells will be backfilled with bentonite or cement.

The EPA will be notified according to conditions in 40 CFR §144.51 and the SD DENR will be notified based on conditions in ARSD 74:55.

15.1.1 Plugging and Abandonment Report

According to EPA 144.51(p) and ARSD 74:29:11:44 the operator is to notify the agencies within 60 days after plugging or at the time of the next quarterly report (whichever is less), a Plugging and Abandonment Report will be submitted to the EPA. The person that performs the plugging operation will certify the report as accurate. The report will contain either:

- A statement that the well was plugged in accordance with the approved Plugging and Abandonment Plan.
- If the actual plugging differed from the Plugging and Abandonment Plan, a statement specifying the different procedures followed will be submitted.

Documentation will be provided to verify that the quantity of sealing material placed in the well is at least equal to the volume of the empty hole.

The Plugging and Abandonment Reports will be retained for at least 3 years from the date of the submission unless the EPA requests an extension. If requested, at the conclusion of the retention period, the reports will be delivered to the EPA.

16.0 Attachment R - Necessary Resources

Table 16.1 provides a breakdown of the costs for plugging and abandoning the injection, extraction and monitor wells associated with the first well field planned for production in the Burdock area. The cost estimate is based on a total of 377 wells and includes a cost per well line item. The plugging costs are based on the diameter of wells, a nominal 5 inches, and the depth, approximately 600 feet, and the number of wells.

Table 16.1: Well Plugging and Abandonment Cost Estimate

Unit cost per well (assume average depth of 650 feet)			
Materials			
5" diameter casing =		0.136	Cubic ft/ft
Average well depth =		650	ft
Cubic ft per well =		88.4	CF
Cement grout cost =		9.00	$/cubic ft
Cement grout cost/well		795.60	$/well
Equipment and Labor			
Contractor crew and equipment - estimated at $125/hour			
Mobilzation/Demob ($11,000 over 377 wells)		30.00	$/well
Well plugging		375.00	
Demolition of well heads and backfill		95.00	
Equipment and Labor cost/well		500	$/well
Total abandonment cost/well =		1,300	$/well
1st Wellfield			
Monitoring wells #wells =	140	182,000	$
Production and Injection wells #wells =	237	308,100	$
Total Estimated Well Abandonment		**490,000**	**$**

Following review and approval of the plugging and abandonment cost estimate, a surety instrument acceptable to EPA will be submitted to the EPA to assure the required plugging and abandonment activities will be completed to safeguard potential USDWs.

The PA is potentially subject to multiple surety requirements. In addition to EPA, the SD DENR and the NRC have surety requirements that must be satisfied. The applicant will submit one surety instrument for well plugging and the agencies must agree who is the lead agency responsible. The suggestion of the applicant is that the SD DENR will be the lead agency with the EPA and the NRC negotiating a Memorandum of Understanding with the SD DENR to consolidate the surety requirements with the SD DENR. The NRC allows the licensee the following options:

Financial surety arrangements generally acceptable to the Commission are:

1. Surety bonds.
2. Cash deposits.
3. Certificates of deposits.
4. Deposits of government securities.
5. Irrevocable letters or lines of credit.
6. Combinations of the above or such other types of arrangements as may be approved by the Commission. However, self insurance, or any arrangement which essentially constitutes self insurance (e.g., a contract with a State or Federal agency), will not satisfy the surety requirement since this provides no additional assurance other than that which already exists through license requirements. (10 CFR Part 40, Appendix A, Criterion 9)

The State of South Dakota provides similar options. (SD Mined Land Reclamation Act, Chapter 45-6B-21 through 24) The State of South Dakota is willing to consider surety arrangements with federal agencies. "The board [Minerals and Environment] shall also consider any surety or cash bond for the proposed mining operation required by an agency of the federal government which surety is required for reclamation purposes." (45-6B-21)

Considering the potential for multiple bond requirements by two federal agencies and one state agency, Powertech is unable to commit to a specific surety instrument at this time. However, upon approval of the UIC Class III Permit, or shortly thereafter, Powertech will provide the approved surety, or evidence thereof (as allowed by 40 CFR Part 144.65), to the EPA.

17.0 Attachment S - Aquifer Exemption

The following attachment describes the justification for the aquifer exemption at the PA.

17.1 Introduction

Some aquifers or portions of aquifers which meet some of the criteria of the regulatory definition of a USDW may not reasonably be expected to serve as a source of drinking water due to high TDS and natural occurring constituents in concentrations not approved by the EPA for human consumption; this is the case in most aquifers where naturally occurring uranium is mineralized. Regulations allow EPA to exempt portions of these aquifers from definition as USDWs and thus allow continued or future injection into them.

The area within the aquifer exemption boundary (Figure 17.1) has a horizontal and a vertical extent. The vertical extent is bounded by upper and lower confining zones as described in Attachment D – Maps and Cross Section of USDWs, Attachment F – Maps and Cross Sections of Geologic Structure of Area and Attachment I – Formation Testing Program. The horizontal extent is based on the area of commercially producible ore deposits, the area around the ore body where the lixiviant is expected to travel during mining of the ore deposits, post-mining aquifer restoration, and a buffer area that includes a monitor well ring and an area beyond the monitor wells that provides room to recover any excursions that may occur.

In order to obtain an aquifer exemption, a demonstration must be made that the aquifer or portions thereof meets the following criteria (USEPA, 2002a):

- The aquifer does not currently serve as a source of drinking water.
- It cannot now and will not in the future serve as a source of drinking water because:
  - It is mineral, hydrocarbon, or geothermal energy producing.
  - It is situated at a depth or location which makes recovery of water economically or technologically impractical.
  - It is so contaminated that it would be impractical to make the water fit for consumption.
  - It is located over a Class III well mining area subject to subsidence or catastrophic collapse.

- Or the TDS content of the ground water is more than 3,000 milligrams per liter (mg/L) and less than 10,000 mg/L, and the aquifer is not reasonably expected to supply a public water supply.

The justification for the aquifer exemption at the PAA is provided below.

17.2 Aquifer Exemption Basis

The aquifer within the project area to be considered for the exemption includes the lateral extent of the Lakota and Fall River sub aquifer units of the Inyan Kara within the production zone and a buffer zone that will allow a reasonable length of time to contain and recover any potential excursions from the well fields (Figure 17.1). This portion of the Inyan Kara being recommended for exemption cannot now and will not in the future serve as a source of drinking water based on the following criteria:

- This portion of the aquifer requested for exemption does not serve as a source of drinking water.
- It contains minerals that considering their quantity and location are expected to be commercially producible.
- The aquifer is so contaminated that rendering the water fit for human consumption would be economically or technologically impractical.

Additional details related to the criteria given above are discussed in the following sub-sections.

17.2.1 Aquifer Exemption Boundary

The proposed exempted area within the project area includes the Lakota formation and the Fall River formation, which together comprise the Inyan Kara aquifer that bounds the Lakota and Fall River formations within the production zone. The extent of the proposed exempted area would also include a buffer zone that will allow a reasonable length of time to contain any potential excursions from the well fields and provide the operator sufficient amount of room for restoration activities that may include flare (Figure 17.1).

Spatial considerations are important when designating portions of an aquifer for exemption; however, there are legal and technical based criteria, guidance, and evaluations that Powertech also considered before proposing the aquifer exemption for the PAA these include:

- Criteria found in §146.4 for exempted aquifer.

- Data criteria necessary to demonstrate the aquifer is expected to be mineral or hydrocarbon producing located in §144.7(c)(1).
- The EPA Ground Water Protection Branch (GWPB) Guidance #34 was looked over closely.
- Historical and recent exploration and development projects were also considered in order to make the soundest decision as stewards of the environment and as a corporation.
- Guidance from EPA Region VIII was carefully considered in establishing the horizontal limits of the proposed AEB.

17.2.2 Horizontal Boundary Justification

The PA proposed AEB is shown on Figure 17.1. This boundary is being proposed to assure the protection of USDW's outside of the AEB. The justification for the proposed AEB distance of 1600 feet from the production zone takes into consideration the location of the monitoring well network, potential seepage velocity and response time needed to reduce concentrations of indicator parameters to acceptable levels at the monitoring wells through pullback to the production area.

In order to determine the extent and configuration of the AEB, a worst case seepage velocity of 10 feet/day has been assumed. This assumption is based on the rate of flow mining fluids can move in the mining zone and the hypothetical case of some unknown and unforeseen preferential flow pathways and a nearby well(s) pumping at a high rate. This assumption and a reasonable response time of 120 days to control an excursion results in 1200 feet for the distance between the monitoring well ring and the AEB. The response time of 120 days includes the time from the initial detection at the monitoring well and implementation of corrective action resulting in the creation of a positive response indicating that recovery of the excursion and its pullback into the production area has been initiated. The monitoring well ring will be located 400 feet from the production zone. This distance has been proven through years of industry practice and, historical application has demonstrated adequacy of this well placement method.

Central Burdock Area

Powertech proposes to include the Inyan Kara Formation in the central Burdock area (CBA) in its proposed AEB. The surface area of the proposed CBA, approximately 776 acres or 11 percent of the total AEB proposed, is that area containing the proposed CPP and ancillary facilities and that is largely surrounded by the uranium deposits/mine units identified in the Burdock area of the

proposed permit area (Figure 17.1). The area is recommended for inclusion based on the following rationale.

- The CBA is a region which will become isolated from sources of recharge as it will be surrounded by well field activities which will have a consumptive use of water. Due to the mining areas surrounding the CBA, operation of any well within the exempted formation will intensify drawdown and potentially have a significant impact on the mining activities surrounding the area. It is expected that lixiviant and mining fluid control within the monitoring well ring would become considerably more difficult.

- The area contains numerous oxidation/reduction fronts that were previously identified or postulated by TVA during its exploration of the area in the 1970s that likely contains uranium mineralization (Plate 17.1). The area will be explored during the term of the permit to determine the nature and quantity of any uranium mineralization in the area.

- The central Burdock area is nearly surrounded by known uranium deposits. The likelihood of anyone in the future installing a drinking water well into the Lakota within the central Burdock area is remote. The presence of known uranium deposits in the area and the history of uranium mining surrounding the area, both open pit and in situ (after Powertech), will be strong deterrents to developing water supply wells in the CBA.

- Considering that the majority of deposits in the Burdock area are located in the Lakota formation, the probability is high that any additional resources identified in the central Burdock area would be in the Lakota. Based on characterization data from six existing wells completed in the Lakota aquifer, four of the six wells exceed the EPA MCL set for drinking water for dissolved alpha, three exceed the radium 226 MCL and five of the six exceed the proposed EPA MCL for radon (Tables 17.5 and 17.6). Results from groundwater analyses from seven wells drilled by Powertech and completed in the Lakota aquifer, prove six of the seven wells with levels of dissolved alpha well above the EPA MCL for drinking water, four of the seven exceed the radium 226 MCL set by the EPA and all seven exceed the proposed EPA MCL for radon 222 (Table 17.7 and 17.8). Based on results from sampling 13 Lakota wells within the project area, 77 percent exceeded the MCL for dissolved alpha, 54 percent exceeded the MCL for radium 226 and 92 percent exceeded the proposed MCL for radon 222.

- Although the majority of the known deposits are located in the Lakota formation, the Fall River formation also contains known and additional drill indicated potential resources. Based on characterization data from eight wells located within the Fall River, three of the eight existed previous to Powertech acquiring the properties. The remaining five wells were completed by Powertech in order to satisfy a request from SD DENR. The data from the all wells completed in the Fall River formation reflect exceedances of the secondary value set by EPA for total dissolved solids and sulfate.

Of the eight wells sampled, six exceeded the EPA MCL concentrations for dissolved alpha in at least one sampling event. Radium 226 was exceeded within five of the eight wells and all eight exceeded the proposed MCL for Radon 222. Based on sampling events that occurred on eight wells, 48 percent exceeded the MCL for dissolved alpha, 40 percent exceeded MCL for Radium 226 and 100 percent exceeded proposed MCL for Radon 222.

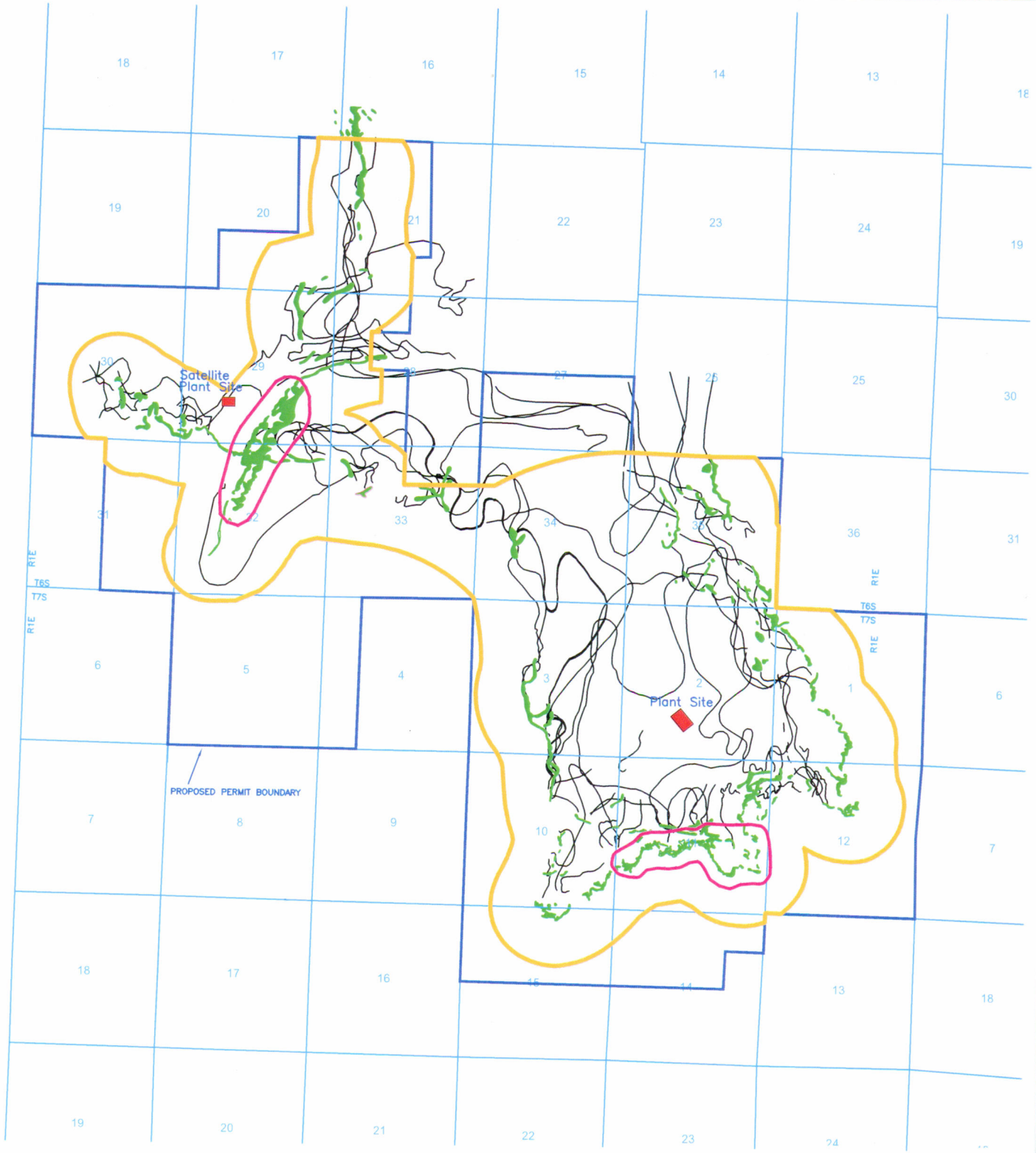
- The cost of additional administrative, legal and technical reviews on the part of the EPA for a new or amended UIC permit application dealing with the central Burdock area would be minimized if EPA would include the area in the AEB requested by this application.

There are no wells within the proposed aquifer exemption boundary that currently serve as sources of drinking water. The Daniel's well was converted to a stock well and a new well was installed by Powertech into the Unkpapa formation.

The aquifer portion recommended for exemption cannot now and will not in the future serve as a source of drinking water based on the following criteria:

- There are no wells within the proposed aquifer exemption boundary that currently serve as sources of drinking water. It contains minerals that considering their quantity and location are expected to be commercially producible.
- The portion of aquifer proposed for exemption is so contaminated that rendering the water fit for human consumption would be economically or technologically impractical.

Additional details related to the criteria given above are discussed in the following sub-sections.



Legend

- Inyan Kara Aquifer Exemption Boundary
- Mine Unit #1 Monitoring Well Ring
- TVA Data - Uranium Roll front Deposits
- Inyan Kara Ore

N

0 5000
SCALE IN FEET

Figure 17.1

Aquifer Exemption Boundaries

NAD 1927 South Dakota South State Plane

DRAWN BY	FL & SMH
DATE	10-Dec-2008
FILENAME	Figure17.1.dwg

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17.2.3 Ore Amenability to Solution Mining

The uranium deposit within the PAA has the geologic and hydrologic features that make a uranium deposit suitable for ISL as detailed in the Nuclear Regulatory Commission Draft Generic Environmental Impact Statement (USNRC, 2008) based on Holen and Hatchell (1986), specifically:

- Deposit geometry is generally horizontal and of sufficient size and lateral continuity to economically extract uranium.
- The sandstone host rock is permeable enough to allow the mining solutions to access and interact with the uranium mineralization.
- The confining layers (Skull Creek Shale and Morrison Formation) will prevent lixiviant from vertically migrating into overlying or underlying aquifers.
- The mineralization to be mined is located in a hydrologically saturated zone.

The amenability of the PA mine zone to ISL methods is demonstrated by the pumping test results presented in Attachment I – Formation Testing Program and the operating information provided in Attachment H – Operating Data and Attachment K – Injection Procedures. Additional information is provided in the following subsections.

17.2.3.1 Lixiviant Compatibility with Ore Body

Laboratory bottle roll tests have been conducted by Energy Laboratories of Casper Wyoming on ore samples from both the Fall River formation and Lakota formation using a simulated lixiviant composed of hydrogen peroxide and sodium bicarbonate dissolved in deionized water.

In the tests, a crushed ore sample was successively contacted with five pore volumes (PVs) of fresh lixiviant for a total of six leach cycles comprising a total of 30 PVs of lixiviant. After each leach cycle, uranium and other dissolved specie concentrations were measured. Results of these leach studies are shown in Table 17.1. Four separate tests were conducted, with one ore sample from the Lakota formation and three ore samples from a single hole in the Fall River formation. The ore samples had ore grades ranging from 0.07 to 0.70 wt% uranium, and produced pregnant lixiviants with uranium concentrations as high as 1600 mg/L. Over the course of the 30 PV test, analysis of the resulting leach solutions indicated uranium recoveries of 59 to 90 percent.

In all four tests, vanadium was also observed to mobilize. Vanadium grades ranged from 60 to 650 milligram per kilogram (mg/kg) in the core samples, and appeared in pregnant lixiviant at concentrations as high as 101 mg/L. Sulfate was also generated in the tests with lixiviate concentrations as high as 715 mg/L for Hole 11-4C and 250 mg/L for Hole 32-2C. While the sulfate may be due to oxidation of pyrite, the observed leach rates and oxidation-reduction potential measurements indicated that sulfur oxidation did not appear to have a negative impact on uranium recovery.

Table 17.1: Results of Laboratory Leach-Amenability Study

		Hole 11-4C	Hole 32-2C		
	Formation	Lakota	Fall River		
Ore Grade	Wt% U	.07	.20	.74	.14
U Recovery	%	76.6	58.6	73.5	89.9

17.2.3.2 Mineralogy of the Uranium Ore

The uranium mineralization is present as a coating on the sand grains and within the pore spaces of Inyan Kara sandstone. Within the Edgemont Uranium District, the dominant uranium minerals are coffinite and uraninite with minor paramontroseite, haggite, fourmarierite, carnotite, and tyuyamunite (Schnabel, 1963). Based on TVA core assays, the uranium is often associated with vanadium in a ration of 1:1.5. The samples tested come from several different mineralized zones but may or may not be representative of the majority of the mineralization throughout the project site.

17.2.4 Commercially Producible

The commercial producibility of the PA, also referred to as the economic viability of the project, is based on capital equipment and operating costs from information gathered during 2007 and 2008, and utilizes standard estimation techniques including quotations and vendor estimates.

This economic study was based upon total estimated project resources of 7.6 million (M) pounds U_3O_8 and an estimated recovery rate of 75 percent. A total producible reserve of 6.049 M lbs U_3O_8 was used for the economic study. This is believed to be a minimum basis for the total amount of resource available within the project area. Several areas are known to have significant resources but are not yet included as the data required to complete resource estimation is not yet available. Project economics will be expected to improve dramatically with the inclusion of all the potential resources within the proposed permit boundary. Based on a study performed by the

Tennessee Valley Authority (TVA), Plate 17.1, as much as 23 M lbs U_3O_8 exists in the project area, which is nearly three times the amount of resource used in this economic evaluation.

The spot price of uranium during the year 2008 has fluctuated between \$90/pound U_3O_8 and \$45/pound U_3O_8. As of December 1, 2008 the price was \$55/pound U_3O_8. Long Term price indicators were reported by Trade Tech at \$70/pound U_3O_8 as of December 1, 2008 (all information as per TradeTech, LLC. 2008). Powertech's estimated cost of production for the PA is sufficiently below the long time price indicator to result in an acceptable rate of return for the shareholders of the company. This conclusion was reinforced by recent investments and due diligence review. Powertech's economic study is considered proprietary and confidential business information thus will not be included with this application. However, Powertech will share this information with the EPA and SD DENR to the extent necessary to demonstrate the project is commercially producible.

17.2.4.1 Uranium Extracted

Total production from both sites is expected to produce approximately 1,000,000 pounds of U_3O_8 per year.

17.2.5 Groundwater Quality

The groundwater characterization study was conducted for the PAA. The groundwater sampling program is summarized in the Baseline Sampling Plan (Respec, 2008a). To support the Baseline Sampling Plan, a Quality Assurance Project Plan (QAPP) has been implemented following the guidance provided by the U.S. Environmental Protection Agency (USEPA, 2002b and 2006) (Respec, 2008b).

For the baseline groundwater study, 19 groundwater wells (14 existing and 5 newly drilled) were selected as a representative sampling group for the area (Figure 17.2). Initial baseline sampling of these wells was conducted quarterly from July 2007 through June 2008. Also as required by the SD DENR (rule ARSD 74:29), an additional 12 wells were sampled monthly beginning in March 2008 and will continue to be sampled through February 2009 (Figure 17.3).

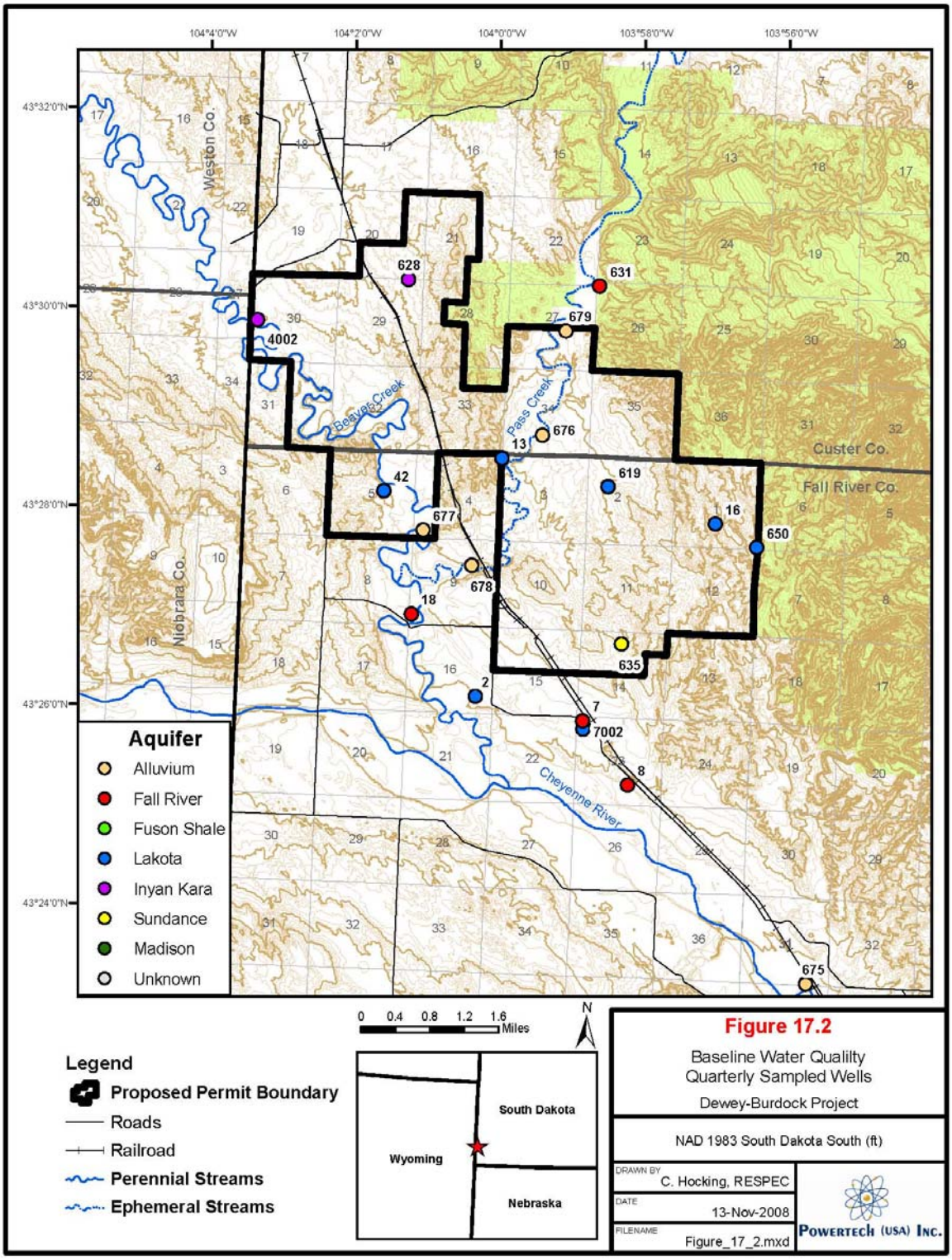

Figure 17.2: Baseline Water Quality Quarterly Sampled Wells

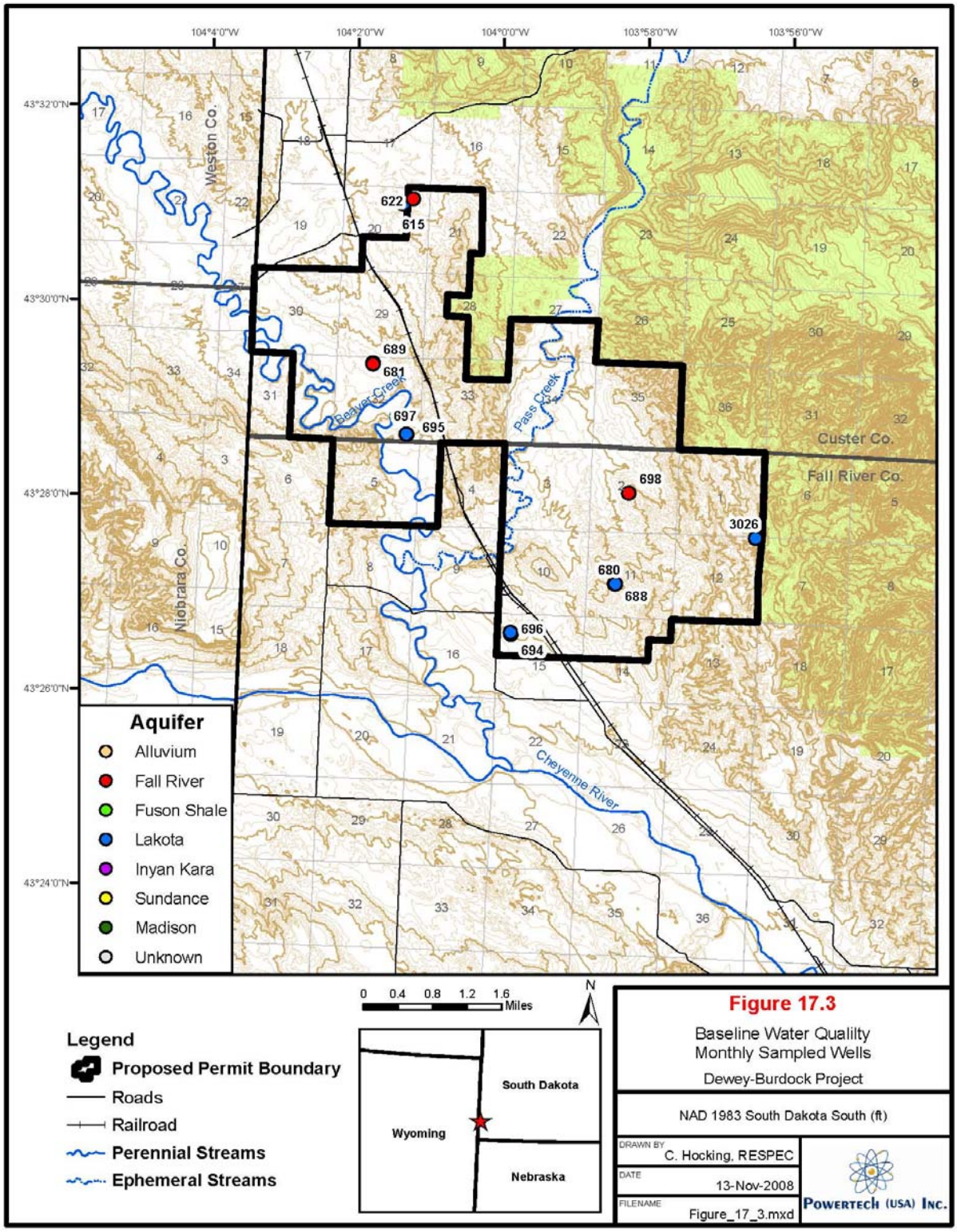

Figure 17.3: Baseline Water Quality Monthly Sampled Wells

17.2.6 Groundwater Restoration Method

For ISL operations, a typical commercial groundwater restoration program consists of a restoration stage and a monitoring stage. The proposed project restoration schedule, Figure 17.4, shows the estimated schedule for restoration. This is a preliminary schedule based on current knowledge of the area, and is based on completion of the production activities for both the Dewey and Burdock sites. As the project is developed, the restoration schedule will be further refined. The restoration stage commonly consists of groundwater sweep and groundwater treatment. The methods of water disposal will provide two options during the ground water treatment stage and some variations exist between the two options. The expected waste disposal method during restoration could be any or all of the following:

1. Deep well injection
2. Land application with pre-treatment
3. Any combination of A and B

Potential use of deep disposal well(s) will allow use of reverse osmosis (RO) in the treatment phase with permeate from the RO being re-injected into the well field being restored. In the case of land application as a disposal method, a fresh water source is required for injection into the well field during restoration. a The reasons for this are that deep disposal wells are expected to allow disposal of RO reject which has TDS levels that are expected to be unsuitable for land application.

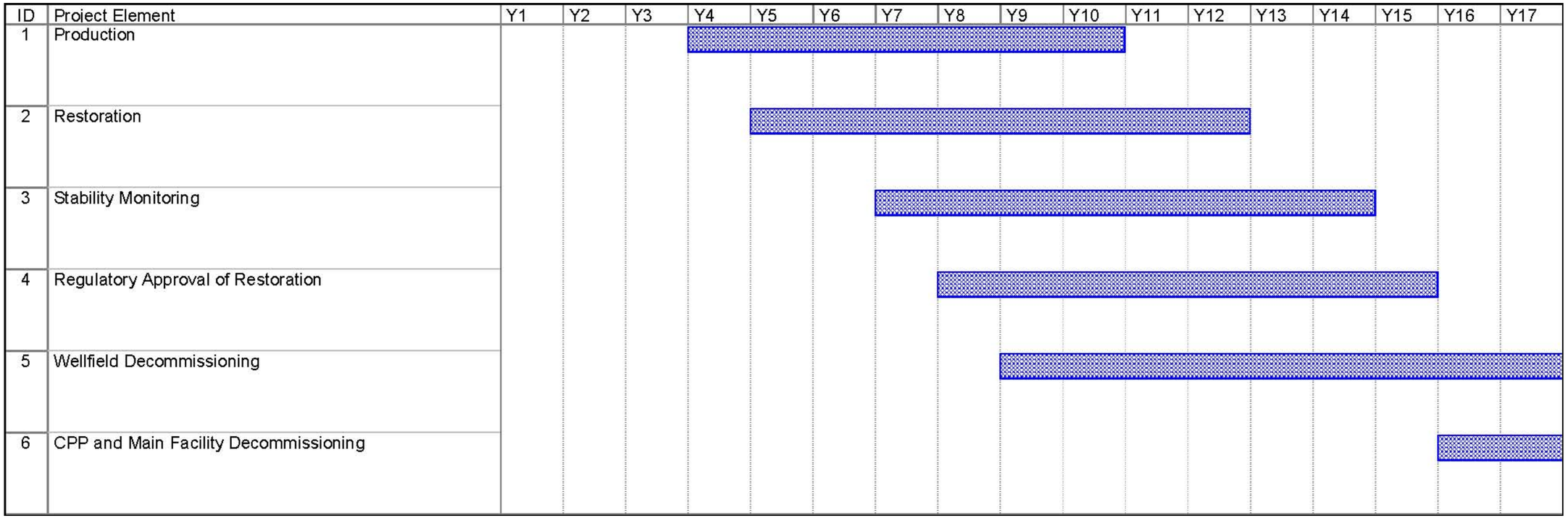

Figure 17.4: Proposed Groundwater Restoration Schedule

The primary goal of groundwater restoration at the site will be to return groundwater quality within the production zone of a well field consistent with pre-operational baseline water quality conditions or to standards consistent with NRC's application of Criterion 5B(5) of Appendix A to 10 CFR Part 40. In the event that Powertech is unable to restore such groundwater consistent with preoperational baseline water quality conditions, the secondary goal would be to return water quality to its pre-operational livestock watering and agricultural class of use. Prior to operation, the baseline groundwater quality will be determined through the sampling and analysis of water quality indicator constituents in wells screened in the mineralized zone(s) across each well field. Based on statistical analysis of the data following ASTM Standard D 6312 (ASTM, 2001) to determine the baseline range of statistical variability of an indicator constituent; TRGs will be established. Powertech will utilize best practicable technology to meet the TRG established for each constituent during the groundwater restoration process. Some of the parameters listed in Table 17.3 will provide the constituents used for establishing groundwater TRGs.

Powertech will consult with SD DENR concerning the specific groundwater suite of constituents prior to well field baseline evaluation. In the event that secondary groundwater restoration standards may need to be considered for specific constituents, Powertech will provide data and justification for restoring groundwater water quality to pre-operational class of use.

In order to estimate post-production water quality from ISL operations at the PAA, Powertech has reviewed operational restoration water quality data from six ISL operations in the western United States. These sites include:

- Irigaray/Christensen Ranch (Wyoming)
- Crownpoint (New Mexico)
- Crow Butte (Nebraska)
- Bison Basin (Wyoming)
- Smith Ranch/Highland (Wyoming)
- Ruth (Wyoming)

Based on this review, the Crow Butte site was selected for the estimate because of the proximity and similar geologic conditions to the project site, available water quality data, reasonable pore volume estimates to achieve restoration and overall restoration success. The water quality data

for the Crow Butte site is extensive with baseline, post-production, post-restoration, and stabilization period data. Baseline water quality, post-production water quality, post-restoration average water quality and stabilization period average water quality data are provided in Table 17.2 for the Crow Butte Mine Unit No.1. Powertech expects similar baseline and post-production water quality results at the project site.

Table 17.2: Crow Butte Post Mining Water Quality Data Summary

Parameter	Baseline Water Quality	Post-Mining Water Quality	Post-Restoration Average Water Quality	Stabilization Period Average Water Quality
BULK PROPERTIES				
Specific Cond.	1947	5752	1620	1787
pH	8.5	7.35	7.95	8.18
TDS	1170.2	3728	967	1094
CATIONS/ANIONS	4.	5.	6.	7.
Alkalinity	293	875	321	347
Chloride	204	583	124	139
Sulfate	356.2	1128	287	331
TRACE METALS	8.	9.	10.	11.
Manganese	0.11	0.075	0.01	0.02
Arsenic	0.002	0.021	0.024	0.017
Iron	0.044	0.078	<0.05	0.09
Lead	0.031	<0.05	<0.05	<0.01
Uranium	0.092	12.2	0.963	1.73
Vanadium	0.066	0.96	0.26	0.11
RADIONUCLIDES	12.	13.	14.	15.
Radium-226	229.7	786	246.7	303
Notes: All units in mg/L except for pH (standard units), radium (pCi/L), and specific conductivity (µmhos/cm).				

The stability monitoring stage includes a period (typically 6 months to a year) in which the indicator parameters are monitored in order to establish successful restoration.

17.2.7 Flare Factor

According to the NRC, flare factor is defined *as a proportionality factor designed to estimate the amount of aquifer water outside of the pore volume that has been impacted by lixiviant flow during the extraction phase. The flare is usually expressed as a horizontal and vertical*

component to account for differences between the horizontal and vertical hydraulic conductivity of an aquifer material (USNRC, 2003). Horizontal and vertical flares are usually expressed as a multiple of the calculated pore volume. However, according to NUREG/CR-6870, zones with low permeabilities have proven more of a concern than in a well field where the balance is maintained. Powertech will balance well fields on an individual pattern basis. Powertech believes this is the most effective way to mine an in situ well field and is the most effective way to restore groundwater. Powertech will balance individual wells that are in operation and production every day. This method reduces the pore volumes for mining and for restoration and minimizes excursions beyond the flare zone. Powertech's restoration volumes are based on historical experience and are in relation to this method of operation. Upon well field development, inclusive of detailed delineation drilling and completion of well field design, the applicant will be in a position to calculate flare for each well field package that will be provided to EPA, NRC and SD DENR.

Table 17.3 contains the water quality parameters analyzed for the groundwater sampling program. Please refer to Attachment P, Table 14.1, Water Quality Regulatory Limits for the EPA associated with key baseline water quality parameters. The analytical methods utilized and minimum detection limits (MDLs) are consistent with the MDLs provided by Region 8 EPA (Table 17.4).

Table 17.3: Powertech Baseline Water Quality Monitoring Parameters

Test Analyte/Parameter	Units	PQL	Method
BULK PROPERTIES			
pH	pH Units	0.01	A4500-H B
Total Dissolved Solids (TDS)	mg/L	5	A1030 E[1], A2540 C[*]
Conductivity	µmhos/cm	5	A2510B
CATIONS/ANIONS			
Calcium	mg/L	0.5-1.0	E200.7
Chloride	mg/L	1[2]	E300.0
Fluoride	mg/L	0.1	E300.0
Magnesium	mg/L	0.5	E200.7
Oxygen reduction potential	mV		A2580B
Potassium	mg/L	0.5	E200.7
Sodium	mg/L	8-0.8	E200.7
Sulfate	mg/L	5	E300.0
Total Alkalinity (as $CaCO_3$)	mg/L	5	A2320 B
Bicarbonate Alkalinity (as $CaCO_3$)	mg/L	5	A2320 B (as HCO3)
Carbonate Alkalinity (as $CaCO_3$)	mg/L	5	A2320 B
Nitrogen (Ammonia as N)	mg/L	0.1	A4500-NH3 G
Nitrate, NO_3- (as Nitrogen)	mg/L	0.1	E300.0
Nitrite, NO_2- (as Nitrogen)	mg/L	0.1	E300.0
Anion/Cation Balance			A1030 E
TRACE METALS			
Antimony, Sb	mg/L	0.003	E200.8
Aluminum, Al	mg/L	0.1	E200.8
Arsenic, As	mg/L	0.001	E200.8
Barium, Ba	mg/L	0.1	E200.8
Beryllium, Be	mg/L	0.001	E200.7, E200.8
Boron, B	mg/L	0.1	E200.7
Cadmium, Cd	mg/L	0.005[3]	E200.8
Chromium, Cr	mg/L	0.05	E200.8
Copper, Cu	mg/L	0.01	E200.8
Iron, Fe	mg/L	0.03	E200.7
Lead, Pb	mg/L	0.001	E200.8

Table 17.3: Powertech Baseline Water Quality Monitoring Parameters (concl'd)

Test Analyte/Parameter	Units	PQL	Method
Manganese, Mn	mg/L	0.01	E200.8
Mercury, Hg	mg/L	0.001[4]	E200.8
Molybdenum, Mo	mg/L	0.1	E200.8
Nickel, Ni	mg/L	0.05	E200.8
Selenium, Se	mg/L	0.001	E200.8, A3114 B[5]
Silica	mg/L	0.5	E200.7
Silver, Ag	mg/L	0.005[6]	E200.8
Sodium Adsorption Ratio	unitless	0.1	Calculation
Strontium, Sr	mg/L	0.02	E200.7, E200.8
Thallium, Tl	mg/L	0.002	E200.8
Uranium, U	mg/L	0.0003	E200.8
Vanadium	mg/L	0.1	E200.7, E200.8
Zinc, Zn	mg/L	0.01	E200.8
RADIONUCLIDES			
Gross Alpha=Alpha Particles	pCi/L	1.0	E900.0
Gross Beta=Beta Particles and Photons	mRem/Year	2.0	E900.0
Gross Gamma	pCi/L	20	E901.1
Radium-226	pCi/L	0.2	E903.0
Lead-210	pCi/L	1.0	E909.0M
Polonium-210	pCi/L	1.0	RMO 3008
Thorium-230	pCi/L	0.2	E907.0
Thorium-232	pCi/L	0.005[7]	E200.8
Radon-222	pCi/L	100	D5072-92
Notes: PQL - Practical Quantitation Limit			
* TDS & 180 C and TDS Balance (0.80 - 1.20)			
[1] A1030 E Method does not reference a PQL			
[2] Samples from 09/28/07 DewBurdGW 677 had a PQL of 8 mg/L			
[3] Samples from 09/26/07 DewBurd GW 18,02,08,631 had a PQL of 0.01			
[4] Samples from 09/26/07-09/28/07 list a PQL for T-Hg of 0.001 and D-Hg of 0.0002			
[5] Selenium IV and VI - PQL of 0.0010			
[6] Samples from 9/26/07 DewBurd GW 18,02,08,631 had a PQL of 0.01			
[7] Samples from 9/26/07 DewBurd GW 18,02,08,631 had a PQL of 0.001			

Table 17.4: Total Metals, EPA Testing Methods and Permit Limits Identified by Region 8 EPA

Constituent	Regulatory Limit (mg/L)	Standard Type	Applicable EPA Methods	Minimum Detection Limit (mg/L)
Antimony	0.006	MCL	200.8, 200.9	0.003
Arsenic	0.01	MCL	200.7, 200.8, 200.9	0.005
Barium	2	MCL	200.7, 200.8	1
Beryllium	0.004	MCL	200.7, 200.8, 200.9	0.002
Boron	1.4	HA-Lifetime	200.7, 212.3	0.7
Cadmium	0.005	MCL	200.7, 200.8, 200.9	0.0025
Chromium (Total)	0.1	MCL	200.7, 200.8, 200.9	0.05
Copper	1.3	MCL-TT	200.7, 200.8, 200.9	0.65
Iron	5	Region 8 Permit Limit	200.7, 200.9	2.5
Lead	0.015	MCL-TT	200.8, 200.9	0.0075
Manganese	0.8	Region 8 Permit Limit	200.7, 200.8, 200.9	0.4
Mercury (Inorganic)	0.002	MCL	245.1, 245.2, 200.8	0.001
Molybdenum	0.04	HA-Lifetime	200.7, 246.1, 246.2	0.02
Nickel	0.1	HA-Lifetime	200.7, 200.8, 200.9	0.05
Selenium	0.05	MCL	200.8, 200.9	0.025
Silver	0.1	HA-Lifetime	200.7, 200.8, 200.9	0.05
Strontium	4	HA-Lifetime	272.1, 272.2, 200.7	2
Thallium	0.002	MCL	200.8, 200.9	0.001
Uranium	0.03	MCL	200.8, 908.0, 908.1	0.015
Zinc	2	HA-Lifetime	200.7, 200.8	1

Notes:
MCL = Maximum Contamination Level
HA-Lifetime = Health Advisory-Lifetime
MCL-TT = Action level which if exceeded triggers treatment
Region 8 = Region 8 Permit Limit

Four drinking water wells were present that had been completed into the Lakota within the Permit boundary (Plate 3.1) prior to implementation of the baseline groundwater sampling program for the PA. One of these wells is located within the AEB (Figure 17.1). Powertech has replaced the Lakota water well located within the AEB with wells completed in the Unkpapa for the Daniel Ranch (Figure 3.1). The Daniel Ranch drinking water well (16), shown on Figure 17.2, was completed into the Lakota and in close proximity to the ore body at the Burdock site. Since the

beginning of October 2006, water samples have been collected and submitted to Energy Laboratories Inc. for analysis. Tables 17.5 and 17.6 summarize the analytical results for total dissolved solids (TDS), total sulfate, and total chloride; and for radionuclides, respectively, from wells sampled on a quarterly basis; Tables 17.7 and 17.8 present the same analytical results from wells sampled on a monthly basis. Sample results were compared to EPA National Primary Drinking Water Standards (Attachment P, Table 14.1) and are discussed in the following sections.

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Table 17.5: Summary of Key Groundwater Constituents Concentrations From Quarterly Sampled Wells

Parameter	Aquifer	Total Dissolved Solids @ 180C				Sulfate-Total				Chloride-Total			
Units		mg/L				mg/L				mg/L			
Sampling Quarter / Well ID		3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008
Domestic Wells													
2	Lakota	1100	1100	1100	1100	583	577	639	579	10	11	26	9
7	Fall River	1000	1000	990	960	586	567	583	514	12	12	11	11
8	Fall River	962	973	879	973	540	594	455	514	13	12	12	11
13	Lakota	890	890	850	880	488	520	499	442	11	11	10	10
16	Lakota	810	760	780	780	448	428	449	401	5	5	5	4
18	Fall River	990	960	960	940	513	536	537	492	13	13	14	12
4002A	Other Inyan Kara	NS	6.7	6.7	6.8	717	799	842	834	7	7	7	6
7002	Lakota	NS	2.7	2.4	2.6	1620	1750	1750	1780	10	11	9	9
Domestic/Stock Wells													
42	Lakota	960	940	980	930	505	519	505	466	12	13	12	11
Stock Wells													
619	Lakota	2100	1900	2100	2000	1440	1180	1310	1230	9	10	12	9
628	Other Inyan Kara	1800	1300	920	980	1030	635	651	515	82	35	29	42
631	Fall River	1900	2000	2000	2000	1240	1220	1250	1250	10	10	8	10
635	Sundance / Unkpapa	2200	2300	2300	2200	1500	1370	1470	1430	24	23	26	20
650	Lakota	2000	1600	1300	1400	1320	1000	801	825	17	16	19	19
Piezometer													
675	Alluvial	5900	6100	6100	5700 (Rep 4800)	3600	3420	3810	3810 (Rep 3840, 3840)	64	60	75	64 (Rep 64, 64)
676	Alluvial	3000	2900	2500	2600	1790	1720	1670	1760	15	16	14	13
677	Alluvial	8900	9700	9600	9100	4390	4590	4310	4410 (Rep 4410)	1720	1780	1290	1710 (Rep 1710)
678	Alluvial	6000	6100	6000	5400	3220	3440	3620	3740 (Rep 3740)	64	61	96	54 (Rep 94)
679	Alluvial	2500	2600	2500	2500	1580	1500	1420	1440	12	12	13	11

Notes:

Yellow highlights designate concentrations over the EPA MCL

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

ND = Not detected

NS = No sample

Rep = duplicate analysis

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Table 17.6: Summary of Groundwater Radionuclide Concentrations From Quarterly Sampled Wells

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

Notes:

Yellow highlights designate concentrations over the EPA MCL

Blue highlights designate concentrations over the proposed EPA MCL for radon

ND = Not detected

NS = No sample

Rep = duplicate analysis

Table 17.7: Summary of Key Groundwater Constituents Concentrations from Monthly Sampled Wells

Parameter	Aquifer	Total Dissolved Solids @ 180C				Sulfate-Total				Chloride-Total			
Units		mg/L				mg/L				mg/L			
Sampling Quarter / Well ID		Mar-08	Apr-08	May-08	Jun-08	Mar-08	Apr-08	May-08	Jun-08	1-Apr-08	21-Apr-08	28-May-08	25-Jun-08
615	Fall River	675	750	710	680	379	371	399	369	6	4	5	5
622	Fall River	800	940	890	900	470	487	493	481	12	10	10	10
680	Lakota	2200	2300	2300	2500	1280	1360	1290	1410	15	11	12	12
681	Fall River	910	940	900	880	478	466	457	449	17	13	16	15
688	Lakota	690	690	740	770	428	390	398	407	13	10	11	11
689	Fall River	720	760	730	700	421	374	400	366	7	5	5	5
694	Lakota	970	1000	970	960	531	512	493	486	11	9	9	9
695	Lakota	NS	910	920	920	NS	504	530	442	NS	11	11	11
696	Lakota	880	930	930	920	475	475	505	456	15	12	12	12
697	Lakota	840	810	790	810	464	430	456	409	12	8	8	8
698	Fall River	2040	2140	2020	2200	1370	1450	1315	1470	12	9	9	9
3026	Lakota	2300	2300	2400	2700	1470	1520	1480	1790	37	16	15	15

Notes:

Yellow highlights designate concentrations over the EPA MCL

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

ND = Not detected

NS = No sample

Rep = duplicate analysis

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Table 17.8: Summary of Groundwater Radionuclide Concentrations From Monthly Sampled Wells

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

Notes:

Yellow highlights designate concentrations over the EPA MCL

Blue highlights designate concentrations over the proposed EPA MCL for radon

ND = Not detected

NS = No sample

Rep = duplicate analysis

17.2.7.1 Exceedances of Primary Drinking Water Standards

Several groundwater samples collected at the Dewey-Burdock site exceed the National Primary Drinking Water Standards. Tables 17.9 through 17.15 provide constituent concentrations, well ID, and sample date for regulated constituents detected at, or above, MCL levels, from wells sampled on a quarterly and monthly basis. Constituents with samples exceeding the standards include arsenic, lead, uranium, radium-226, and gross alpha particles. Complete groundwater quality data results are available in Appendix H.

Nearly 75 percent of the samples exceeded the MCL for gross alpha particles of 15 picocuries per liter (pCi/L), with the exceedances occurring in samples from the Inyan Kara aquifer and alluvial aquifer (Table 17.9). The range of gross alpha particles in alluvial wells was 13.3 to 129 pCi/L. The range of gross alpha particles in Inyan Kara wells was 1.4 to 6,500 pCi/L. Two of the three wells (680 and 681) having gross alpha concentrations over 1,000 pCi/L are known to be directly within an ore body. The third, 698, is down-gradient of open pit mines within the Fall River Formation.

Table 17.9: Gross Alpha (Total) MCL Exceedances

Well ID	Sample Date	Result, pCi/L	Well Use
7	20-Feb-08	15.5	Domestic
13	20-Feb-08	19.5	Domestic
16	27-Sep-07	62.7	Domestic
16	30-Mar-08	85.7	Domestic
16	30-Jun-08	28.3	Domestic
18	26-Sep-07	15.7	Domestic
18	12-Nov-07	20	Domestic
18	12-Nov-07	18.9	Domestic
18	12-Feb-08	31.7	Domestic
18	30-May-08	27.5	Domestic
42	28-Sep-07	371	Domestic
42	12-Nov-07	375	Domestic
42	5-Feb-08	526	Domestic
42	30-May-08	558	Domestic
615	1-Apr-08	18.2	Monitoring
615	1-Apr-08	17.7	Monitoring
615	21-Apr-08	15.1	Monitoring
615	28-May-08	15.3	Monitoring
615	25-Jun-08	38.3	Monitoring
619	27-Sep-07	367	Stock
619	12-Nov-07	341	Stock
619	24-Mar-08	438	Stock
619	17-Jun-08	398	Stock

Table 17.9: Gross Alpha (Total) MCL Exceedances (cont'd)

Well ID	Sample Date	Result, pCi/L	Well Use
622	1-Apr-08	15	Monitoring
622	21-Apr-08	22.6	Monitoring
622	28-May-08	32.6	Monitoring
622	25-Jun-08	36.4	Monitoring
628	28-Sep-07	29.9	Stock
628	14-Nov-07	83.9	Stock
628	20-Feb-08	64.5	Stock
628	29-May-08	39	Stock
631	26-Sep-07	51	Stock
631	14-Nov-07	46.5	Stock
631	20-Feb-08	162	Stock
631	19-May-08	60.7	Stock
675	28-Sep-07	18.8	Monitoring
675	27-Nov-07	18.3	Monitoring
675	5-Feb-08	29.3	Monitoring
675	29-Apr-08	55.2	Monitoring
675	29-Apr-08	51.1	Monitoring
676	28-Sep-07	37.1	Monitoring
676	27-Nov-07	31.9	Monitoring
676	5-Feb-08	95.5	Monitoring
676	29-Apr-08	51.6	Monitoring
677	28-Sep-07	41	Monitoring
677	27-Nov-07	38.7	Monitoring
677	5-Feb-08	129	Monitoring
677	29-Apr-08	43.1	Monitoring
678	28-Sep-07	23.2	Monitoring
678	27-Nov-07	18.9	Monitoring
678	5-Feb-08	41.5	Monitoring
678	5-Feb-08	30.2	Monitoring
678	29-Apr-08	54.7	Monitoring
679	28-Sep-07	19.9	Monitoring
679	3-Feb-08	18.4	Monitoring
679	18-May-08	22.4	Monitoring
680	30-Jan-08	4090	Monitoring
680	31-Mar-08	6440	Monitoring
680	21-Apr-08	4270	Monitoring
680	13-May-08	6500	Monitoring
680	21-May-08	4500	Monitoring
680	7-Jul-08	4280	Monitoring
680	10-Jun-08	4370	Monitoring
681	30-Jan-08	656	Monitoring

Table 17.9: Gross Alpha (Total) MCL Exceedances (concl'd)

Well ID	Sample Date	Result, pCi/L	Well Use
681	30-Mar-08	2170	Monitoring
681	21-Apr-08	1400	Monitoring
681	12-May-08	2220	Monitoring
681	18-May-08	1220	Monitoring
681	25-Jun-08	1390	Monitoring
681	1-Jul-08	1180	Monitoring
688	10-Jun-08	17.3	Monitoring
688	7-Jul-08	29.8	Monitoring
689	30-Mar-08	64.3	Monitoring
689	21-Apr-08	25.5	Monitoring
689	28-May-08	34.9	Monitoring
689	25-Jun-08	36.5	Monitoring
689	1-Jul-08	33.4	Monitoring
694	21-Apr-08	19.2	Monitoring
694	21-Apr-08	18.1	Monitoring
694	24-Jun-08	23.7	Monitoring
695	22-Apr-08	29.4	Monitoring
695	21-May-08	25.6	Monitoring
695	24-Jun-08	39.7	Monitoring
696	24-Jun-08	23.9	Monitoring
697	31-Mar-08	52.2	Monitoring
698	30-Mar-08	1750	Monitoring
698	30-Mar-08	1880	Monitoring
698	22-Apr-08	2110	Monitoring
698	28-May-08	1210	Monitoring
698	28-May-08	1390	Monitoring
698	24-Jun-08	1790	Monitoring
3026	30-Mar-08	47.6	Monitoring
3026	22-Apr-08	43.8	Monitoring
3026	28-May-08	92.4	Monitoring
3026	24-Jun-08	116	Monitoring
4002	27-Sep-07	141	Stock
4002	27-Sep-07	120	Stock
4002	14-Nov-07	227	Stock
4002	12-Feb-08	314	Stock
4002	19-May-08	127	Stock
7002	28-Sep-07	45.6	Stock
7002	12-Nov-07	39.8	Stock
7002	20-Feb-08	91.4	Stock
7002	29-May-08	29.5	Stock

All samples with gross alpha (total) results equal to or greater than the gross alpha MCL of 15 pCi/L.

Each sample collected from wells 615 and 3026 have exceeded the MCL for arsenic of 0.01 milligrams per liter (mg/L) with concentrations ranging from 0.024 to 0.28 mg/L over the sampling period (Table 17.10). A total of eight samples had lead concentrations exceeding the MCL (0.015 mg/L) ranged from 0.015 to 0.06 mg/L (Table 17.11). Uranium concentrations exceeding the MCL (0.03 mg/L) ranged from 0.0322 to 0.687 mg/L, and half of all the uranium exceedances were from alluvial aquifer samples (Table 17.12). Radium 226 (dissolved), Radium 226 (suspended) and Radium (total) concentrations exceeding the MCL (5.0 pCi/L) are presented in Table 17.13 – 17.15, respectively.

Table 17.10: Arsenic (Total) MCL Exceedances

Well ID	Sample Date	Result, mg/L	Well Use
615	1-Apr-08	0.024	Monitoring
615	1-Apr-08	0.025	Monitoring
615	21-Apr-08	0.024	Monitoring
615	28-May-08	0.024	Monitoring
615	25-Jun-08	0.024	Monitoring
676	5-Feb-08	0.021	Alluvial Monitoring
679	18-May-08	0.011	Alluvial Monitoring
3026	30-Mar-08	0.023	Monitoring
3026	22-Apr-08	0.022	Monitoring
3026	28-May-08	0.028	Monitoring
3026	24-Jun-08	0.025	Monitoring

All samples with arsenic (total) results equal to or greater than the arsenic MDL of 0.01 mg/L.

Table 17.11: Lead (Total) MCL Exceedances

Well ID	Sample Date	Result, mg/L	Well Use
622	21-Apr-08	0.026	Monitoring
622	28-May-08	0.023	Monitoring
622	25-Jun-08	0.03	Monitoring
650	24-Mar-08	0.05	Discontinued Stock
676	5-Feb-08	0.06	Alluvial Monitoring
679	3-Feb-08	0.015	Alluvial Monitoring
679	18-May-08	0.022	Alluvial Monitoring
689	25-Jun-08	0.017	Monitoring

All samples with lead (total) results equal to or greater than the lead MDL of 0.015 mg/L.

Table 17.12: Uranium (Total) MCL Exceedances

Well ID	Sample Date	Result, mg/L	Well Use
675	5-Feb-08	0.0387	Alluvial Monitoring
675	29-Apr-08	0.0502	Alluvial Monitoring
675	29-Apr-08	0.0516	Alluvial Monitoring
676	5-Feb-08	0.0687	Alluvial Monitoring
676	29-Apr-08	0.0591	Alluvial Monitoring
677	5-Feb-08	0.0414	Alluvial Monitoring
677	29-Apr-08	0.0471	Alluvial Monitoring
678	5-Feb-08	0.0379	Alluvial Monitoring
678	5-Feb-08	0.0352	Alluvial Monitoring
678	29-Apr-08	0.0387	Alluvial Monitoring
680	31-Mar-08	0.0541	Monitoring
698	30-Mar-08	0.123	Monitoring
698	30-Mar-08	0.122	Monitoring
698	22-Apr-08	0.119	Monitoring
698	28-May-08	0.116	Monitoring
698	28-May-08	0.119	Monitoring
698	24-Jun-08	0.113	Monitoring
3026	28-May-08	0.0322	Monitoring

All samples with uranium (total) results equal to or greater than the radium-226 MDL of 0.03 mg/L.

Table 17.13: Radium 226 (Dissolved) MCL Exceedances

Well ID	Sample Date	Result pCi/L	Well Use
16	27-Sep-07	26.2	Domestic
16	12-Nov-07	8.1	Domestic
16	30-Mar-08	15.3	Domestic
16	30-Jun-08	6.4	Domestic
42	28-Sep-07	96.5	Domestic
42	12-Nov-07	102	Domestic
42	5-Feb-08	100	Domestic
42	30-May-08	100	Domestic
615	25-Jun-08	7.2	Monitoring
619	27-Sep-07	120	Stock
619	12-Nov-07	100	Stock
619	24-Mar-08	99.7	Stock
619	17-Jun-08	110	Stock
628	28-Sep-07	7.4	Stock
628	14-Nov-07	20.7	Stock
628	20-Feb-08	9	Stock
628	29-May-08	6.1	Stock
631	26-Sep-07	12.9	Stock
631	14-Nov-07	9.5	Stock
631	20-Feb-08	19.4	Stock
631	19-May-08	22.1	Stock
680	30-Jan-08	1180	Stock
680	31-Mar-08	1150	Monitoring
680	21-Apr-08	1230	Monitoring
680	13-May-08	1430	Monitoring
680	21-May-08	1240	Monitoring
680	10-Jun-08	1410	Monitoring
680	7-Jul-08	1280	Monitoring
681	30-Jan-08	421	Monitoring
681	30-Mar-08	414	Monitoring
681	21-Apr-08	377	Monitoring
681	12-May-08	407	Monitoring
681	18-May-08	423	Monitoring
681	25-Jun-08	434	Monitoring
681	1-Jul-08	357	Monitoring
688	7-Jul-08	6.7	Monitoring
689	30-Mar-08	7.9	Monitoring
689	28-May-08	5.7	Monitoring
689	25-Jun-08	5.5	Monitoring

Table 17.13: Radium 226 (Dissolved) MCL Exceedances (concl'd)

Well ID	Sample Date	Result pCi/L	Well Use
689	1-Jul-08	7.7	Monitoring
695	22-Apr-08	5	Monitoring
695	24-Jun-08	5.2	Monitoring
697	31-Mar-08	6.3	Monitoring
698	30-Mar-08	387	Monitoring
698	30-Mar-08	398	Monitoring
698	22-Apr-08	370	Monitoring
698	28-May-08	412	Monitoring
698	28-May-08	413	Monitoring
698	24-Jun-08	429	Monitoring
3026	28-May-08	9.6	Monitoring
4002	27-Sep-07	63.6	Stock
4002	27-Sep-07	60	Stock
4002	14-Nov-07	54.2	Stock
4002	12-Feb-08	57	Stock
4002	19-May-08	52.3	Stock
7002	28-Sep-07	8.5	Stock
7002	12-Nov-07	8.1	Stock
7002	20-Feb-08	8.8	Stock
7002	29-May-08	8	Stock

All samples with radium-226 (dissolved) results equal to or greater than the radium-226 MDL of 5 pCi/L. Radium-228 was not analyzed due to the absence of Thorium-232 in samples.

Table 17.14: Radium 226 (Suspended) MCL Exceedances

Well ID	Sample Date	Result, mg/L	Well Use
42	5-Feb-08	5.1	Domestic
619	24-Mar-08	11.4	Stock
619	17-Jun-08	8.8	Stock
676	5-Feb-08	11.4	Alluvial Monitoring
679	3-Feb-08	9	Alluvial Monitoring
680	30-Jan-08	12.7	Monitoring
680	13-May-08	13.2	Monitoring
681	30-Jan-08	9.9	Monitoring
698	30-Mar-08	15.3	Monitoring
698	30-Mar-08	12.4	Monitoring
698	22-Apr-08	6.4	Monitoring
698	28-May-08	14	Monitoring
698	28-May-08	13.5	Monitoring
698	24-Jun-08	11.6	Monitoring
4002	27-Sep-07	19.4	Stock
4002	12-Feb-08	37	Stock
4002	19-May-08	8.4	Stock

All samples with radium-226 (suspended) results equal to or greater than the radium-226 MDL of 5 pCi/L. Radium-228 was not analyzed due to the absence of Thorium-232 in samples.

Table 17.15: Radium 226 (Total) MCL Exceedances

Well ID	Sample Date	Result, mg/L	Well Use
16	27-Sep-07	17.4	Domestic
42	28-Sep-07	79.7	Domestic
619	27-Sep-07	120	Stock
628	28-Sep-07	6.8	Stock
631	26-Sep-07	15.2	Stock
4002	27-Sep-07	62.7	Stock
4002	27-Sep-07	79.4	Stock
7002	28-Sep-07	6.3	Stock

All samples with radium-226 (total) results equal to or greater than the radium-226 MDL of 5 pCi/L. Radium-228 was not analyzed due to the absence of Thorium-232 in samples.

17.2.7.2 Exceedances of Other Drinking Water Standards

In addition to primary drinking water standards established by the US EPA, EPA Region 8 has set additional primary standards for manganese and iron. Radon-222 also has a proposed standard of 300 pCi/L that has not yet been adopted. Secondary drinking water standards (SMCLs) set by the EPA are designated for constituents that alter the color, taste, and odor of water. These constituents are not considered health risks but may deter human consumption when concentrations are above the SMCL. These constituents, along with the number of samples that exceed these guidelines, are also presented in Table 17.16, as discussed below.

Table 17.16: Water Quality Regulatory Limits for Public Drinking Water Supply Systems

Test Analyte/Parameter	Units	EPA Maximum Contaminant Level (MCL)	Number of Samples Analyzed*	Number of Detections	Number of Detections equal to or above MCL
BULK PROPERTIES					
pH	pH Units	6.5- 8.5 [1]	141	141	6
Total Dissolved Solids (TDS)	mg/L	500 [1]	141	141	141
CATIONS/ANIONS					
Sodium, Na	mg/L	200 [1]	141	141	63
Chloride, Cl	mg/L	250 [1]	141	141	4
Fluoride, F	mg/L	4; 2[1]	141	136	0
Sulfate, SO4	mg/L	250 [1]	141	141	141
Nitrate (as Nitrogen)	mg/L	10	141	29	0
Nitrite (as Nitrogen)	mg/L	1	141	0	0
Nitrate and Nitrite (Combined)	mg/L	10	141	29	0
TRACE METALS (total)**					
Antimony, Sb	mg/L	0.006	98	0	0
Aluminum, Al	mg/L	0.05-0.2 [1]	141	0	0
Arsenic, As	mg/L	0.01	98	80	11
Barium, Ba	mg/L	2	98	6	0
Beryllium, Be	mg/L	0.004	98	2	0
Boron, B	mg/L	1.4 [2]	98	29	3
Cadmium, Cd	mg/L	0.005	98	0	0
Chromium, Cr	mg/L	0.1	98	1	0
Copper, Cu	mg/L	1.0 [1]; 1.3 [3]	98	5	0
Iron, Fe	mg/L	0.3 [1]; 5 [4]	98	95	2 [1], 1 [4]
Mercury, Hg	mg/L	0.002	170	1	0

Table 17.16: Water Quality Regulatory Limits for Public Drinking Water Supply Systems (concl'd)

Test Analyte/Parameter	Units	EPA Maximum Contaminant Level (MCL)	Number of Samples Analyzed*	Number of Detections	Number of Detections equal to or above MCL
Manganese, Mn	mg/L	0.05 [1]; 0.8 [4]	98	98	89 [1], 19 [4]
Molybdenum, Mo	mg/L	0.04 [2]	98	8	2
Nickel, Ni	mg/L	0.1 [2]	98	1	1
Lead, Pb	mg/L	0.015 [3]	98	18	8
Selenium, Se	mg/L	0.05	98	26	0
Silver, Ag	mg/L	0.1 [1], [2]	98	0	0
Strontium, Sr	mg/L	4 [2]	98	97	37
Thallium, Tl	mg/L	0.002	98	0	0
Uranium, U	mg/L	0.03	102	77	18
Zinc, Zn	mg/L	5 [1]; 2 [2]	98	35	0
RADIONUCLIDES					
Alpha Particles (dissolved)	pCi/L	15	141	141	104
Beta Particles and Photons	mRem/Year	4	141	137	N/A
Radium 226 and 228 (Combined)	pCi/L	5	135	119	59
Radon-222 (total)	pCi/L	300 [5]	121	121	105

Notes:

[1] "Secondary" guideline value above which use of water may give rise to complaints by consumers

[2] Health Advisory-Lifetime

[3] Action level which if exceeded triggers treatment

[4] Region 8 Permit Limit

[5] Proposed MCL

* Number of samples includes results for only those wells that were sampled quarterly or monthly as part of the baseline sampling plan.

**Number of samples analyzed under trace metals is based on samples that were analyzed for total trace metals. Additional samples were analyzed for only the dissolved metal and are not yet included in this analysis.

Bulk water quality properties with SMCLs include pH and TDS. For samples collected as part of the baseline study, six wells exceeded the SMCL for pH with values ranging from 8.6 to 10.3. Almost all of the samples exceeded the recommended concentration of 500 mg/L for TDS. Values of TDS ranged from 2.4 to 9700 mg/L with the highest values obtained from alluvial well samples (Table 17.5 and 17.7).

A number of samples also exceeded the SMCL for sulfate. To date, all 141 samples exceeded the SMCL for sulfate of 250 mg/L; 86 of these samples were over double the limit (over 500 mg/L), and 59 samples were over 1,000 mg/L sulfate. Twelve samples from the quarterly sampled wells had concentrations of sulfate over 3,000 mg/L, all of which were from the alluvial aquifers (Table 17.5).

SMCL exceedances were noted for trace metals including boron, iron, manganese, and strontium. The three exceedances for boron were all collected from well 678 with values from 1.4 to 1.6 mg/L. Nearly half of the samples collected exceeded the SMCL of 0.3 mg/L for iron; 16 samples exceeded the Region 8 limit. The only water supply wells with groundwater exceeding the Region 8 limit for iron are stock wells 619 and 650. The SMCL for manganese was exceeded in 89 of 98 samples; the Region 8 limit of 0.8 mg/L was exceeded in 19 samples. Values of manganese over the secondary guideline range from 0.05 to 3.4 mg/L. Strontium levels were exceeded in 37 of 98 samples analyzed with values ranging from 4.2 to 11.6 mg/L. The alluvial wells had the highest values for exceeded trace metal including boron, iron, manganese, and strontium.

Currently, there is no regulatory drinking water standard for Radon-222. The proposed MCL is 300 pCi/L. Of the 121 samples analyzed for Radon-222 as part of the Dewey-Burdock baseline sampling program, 105 samples exceed the proposed MCL. Values of samples exceeding the limit range from 304 to 462,000 pCi/L (Tables 17.6 and 17.8). Thirty-six samples have over 10 times the proposed MCL for radon-222; 20 of these samples are over 100 times the proposed MCL. The wells with the highest concentration include wells 680 and 681 (Table 17.8), which are directly in a known ore body, and well 42 (Table 17.6), a private well used for domestic and stock water. The only well that did not have an exceedance of the radon-222 limit is well 650 (Table 17.6), a Lakota well up-gradient of historic uranium mining activities.

17.2.7.3 Not Fit for Human Consumption

Based on the baseline sampling results, the groundwater contained within the ore zones has concentrations of radionuclides beyond levels that are practical to render fit for human consumption. The aquifer does not presently, and will not in the future, serve as a source of drinking water because the concentrations of radionuclides in groundwater are well in excess of EPA MCLs and TDS concentrations significantly exceed SMCLs in all wells (Tables 17.5, 17.6, 17.7 and 17.8). Therefore, rendering the water fit for human consumption would be economically and technologically impractical.

No drinking water wells are extracting water from the Fall River or Lakota formations in the area requested for exemption. During initiation of baseline sampling program, a single domestic well completed into the Lakota formation was present within less than one mile of the proposed aquifer exemption boundary. Water quality samples from this well (16), (E 1009827.637, N 434446.9008) were elevated above the EPA MCLs for alpha particles, radium-226 and radon-222 (Table 17.6). Powertech replaced the well with a well completed into the Unkpapa aquifer.

17.3 Project Schedule

Following the issuance of the all required permits and licenses, it is anticipated that construction of the Burdock Well field 1, the central processing plant and ancillary facilities including evaporation ponds will commence early in the first quarter 2011. The construction of the Dewey Well field 1 and ancillary facilities will follow shortly thereafter (Figure 17.5). Start-up of the Dewey and Burdock operations will commence during the fourth quarter 2011 and continue for approximately 8 to 10 years during which additional well fields will be completed along the roll fronts at both Dewey and Burdock sites. It is anticipated that groundwater restoration activities will also be completed within a period that extends three years past the end of the production as we plan to restore the ground water at the same time as we are producing. The projected construction, operation, restoration and decommissioning schedule is provided in Figure 17.6.

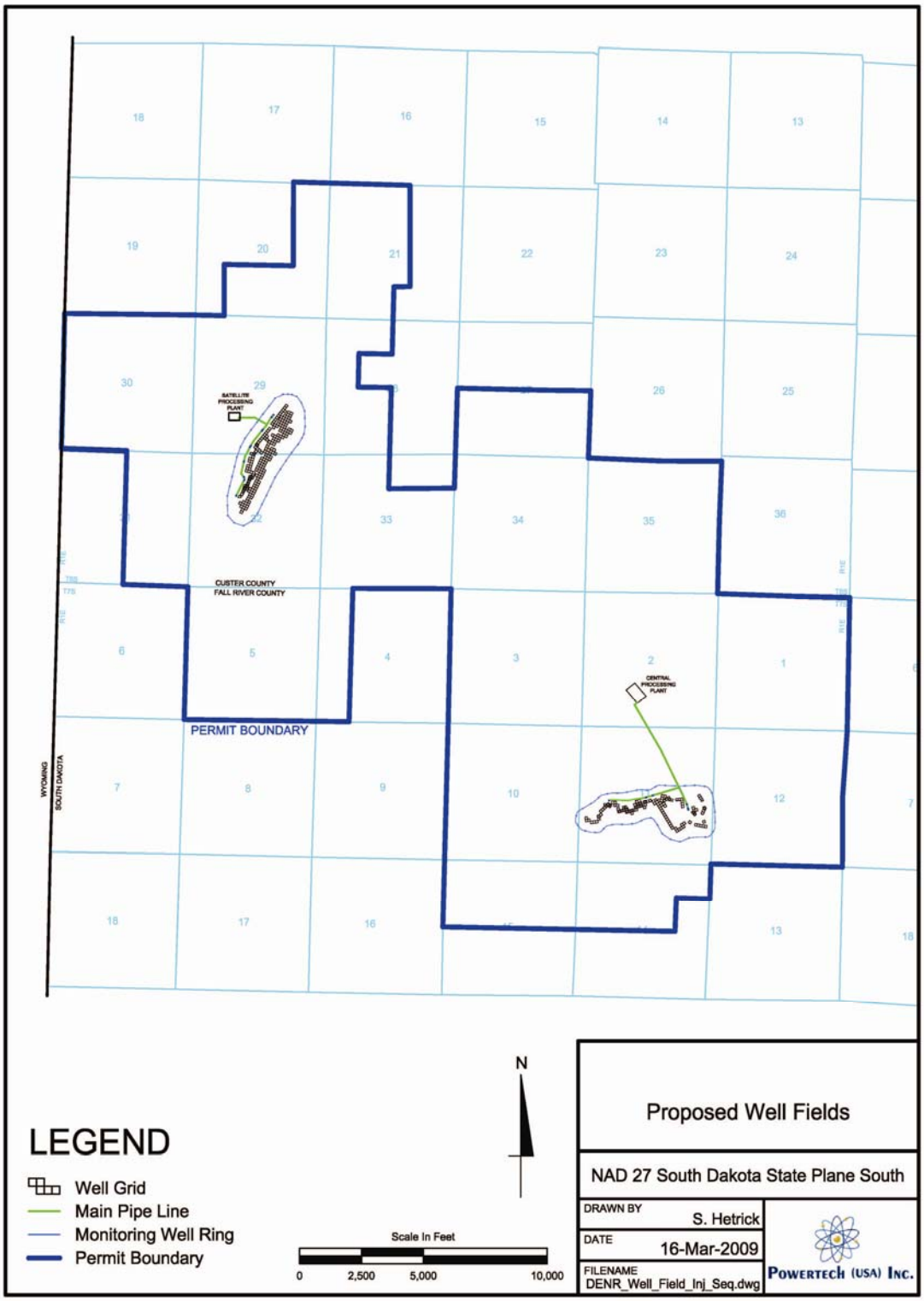

Figure 17.5: Map of Proposed Sequence for Development and Injection into the Well Fields

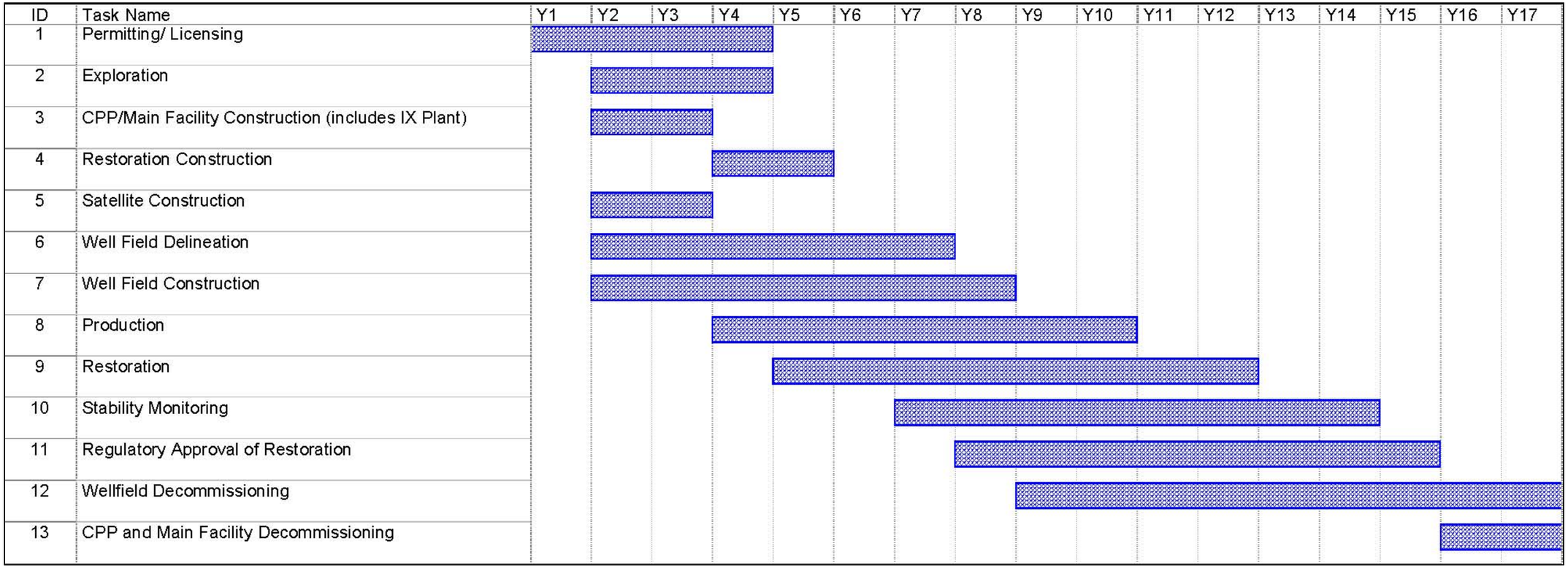

Figure 17.6: Projected Construction, Operation, Restoration and Decommissioning Schedule

Decommissioning of the well fields including well plugging and abandonment, the removal of piping, tanks, ancillary buildings and equipment, cleanup of surface soil to radiological standards and revegetation of disturbed areas will be implemented following the cessation of uranium recovery and groundwater operations at the Dewey and Burdock sites. It is likely that the central processing facility at the Burdock site will continue to operate for several years following the decommissioning of the Dewey-Burdock well fields. The plant will continue to process uranium from other ISL projects such as the nearby satellite Aladdin and Dewey Terrace ISL projects planned in Wyoming.

17.4 Financial Assurance

In compliance 10 CFR Part 40 Appendix A criteria and NUREG-1569 and 1757, Powertech will maintain financial assurance instruments to cover the cost of reclamation including the costs of groundwater restoration, the cost of decommissioning, dismantling and disposal of all buildings and other facilities, and the reclamation and revegetation of affected areas for the project. Table 17.17 and Table 17.18 provide summaries of closure cost estimates for the land application and waste disposal well options, respectively. Detailed cost tables are provided in Appendix I. In accordance with NRC requirements, an updated Annual Surety Estimate Revision will be submitted each year adjusting the surety instrument to reflect existing operations and those planned for construction or operation in the following year. After review and approval of the Annual Surety Estimate Revision by the NRC, Powertech will revise the surety instrument to reflect the updated amount.

Table 17.17: Summary of Closure Costs - Land Application

No.	Cost Item Proposed Action Land Application Only	Cost
1	Water Treatment Equipment (provided with initial project construction)	-
2	Groundwater Restoration Cost	2,387,000
3	Well Closure	490,000
10	Contingency at 15%	431,550
	Total Restoration and Reclamation Cost	**3,308,550**

Table 17.18: Summary of Closure Costs - Waste Disposal Well

No.	Cost Item Proposed Action Waste Disposal Well Only	Cost
1	Water Treatment Equipment	-
2	Groundwater Restoration Cost	1,877,000
3	Well Closure	490,000
10	Contingency at 15%	355,050
	Total Restoration and Reclamation Cost	**2,722,050**

17.5 Future Operations

In looking forward, Powertech realizes the potential of locating minable resources within the proposed permit boundary but outside the current proposed aquifer exemption area. In preparation of this possibility, Powertech recommends the inclusion into the mining permit conditions, the ability for minor permit modifications to be submitted and approved via ARSD 74:55:01:26.01 and 74:29:03:16 from the South Dakota Mined Land Reclamation Rules. EPA does not have any such provision, thus an amendment for an extension of the AEB may become necessary in order for Powertech to mine the resources under the corporation's control at a later date. By including the provisions of ARSD 74:55:01:26.01 and 74:29:03:16, it is Powertech's belief this action would save the state time and resources and would produce a more effective and efficient means to implement minor permit modifications in the future.

18.0 Attachment U - Description of Business

This UIC Permit application is being submitted by Powertech (USA) Inc. (Powertech), a South Dakota Corporation and a USA subsidiary of the Canadian parent company, Powertech Uranium Corporation. Powertech Uranium Corp. is a mineral exploration and development company that, through its Denver-based subsidiary, Powertech (USA) Inc., holds the Dewey-Burdock uranium deposit in South Dakota, the Centennial Project in Colorado and the Dewey Terrace and Aladdin projects in Wyoming. The company's key personnel have over 200 years of experience in the uranium industry throughout the United States, and have permitted more than a dozen in situ recovery operations in the United States for production. For more information, refer to Powertech's website at http://www.powertechuranium.com.

The corporate office is located in Vancouver, British Columbia and the United States headquarters office is located Greenwood Village, Colorado. Powertech maintains an exploration office in Hot Springs, South Dakota and operations offices in Wellington, Colorado and Edgemont, South Dakota (addresses shown below). Powertech is a publicly traded company on the Toronto Stock Exchange (TSX) as PWE and the Frankfurt Stock Exchange as P8A.

COLORADO-DTC Powertech (USA) Inc. 5575 DTC Parkway, Suite 140 Greenwood Village, CO 80111	SOUTH DAKOTA - EDGEMONT Powertech (USA) Inc. 310 2nd Avenue P.O. Box 812 Edgemont, SD 57735	NEW MEXICO Powertech (USA) Inc. 8910 Adams Street NE Albuquerque, NM 87113
COLORADO - WELLINGTON Powertech (USA) Inc. 8305 6th Street P.O. Box 1066 Wellington, CO 80549	SOUTH DAKOTA - HOT SPRINGS Powertech (USA) Inc. 145 N. Chicago, Suite C P.O. Box 723 Hot Springs, SD 57747	

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