2.7.2.2.7 Alluvial Aquifers

For the purpose of this report, the alluvial aquifers in the vicinity of the project 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. Groundwater level data and groundwater samples were collected for laboratory analyses.

2.7.2.2.8 Groundwater Flow

The hydrologic investigation of this site included measurement of water levels in wells completed in the Inyan Kara aquifer, the overlying alluvial aquifer, and the underlying aquifer (Sundance/Unkpapa). The data were used to assess groundwater flow direction as indicated by groundwater elevations, to construct potentiometric surfaces and to calculate hydraulic gradient. Data collection and analyses were started in 2007 and are ongoing in order to document pre-development conditions and changes in potentiometric head before, during, and after operations. Appendix 2.7-A lists water level data collected from wells completed in the Inyan Kara aquifer during this study.

Water level data were collected as follows:

- Monthly water levels were measured in wells listed in Table 2.7-14 and shown in Plate 2.5-1. This table summarizes the wells by formation as determined by well completion information or, if well completion information was not available, through analyses of water quality information. These wells were selected to provide water level data upgradient and downgradient of the proposed mine areas.
- Water levels were measured in monitoring wells listed in Table 2.7-14 as follows:
  - Static water levels were measured at most wells prior to sample collection with regard to a reference elevation, usually a mark on the well or on a permanent structure above or near to the well.
  - When possible, free-flowing wells were measured with a 15 lb/in^2 (psi) or 30 psi N.I.S.T.-certified pressure gauge.
  - The well was shut in and the pressure was allowed to stabilize before a reading was recorded.

  - Pressure values were recorded to within at least 0.1 psi and typically to within 0.01 psi.

  - Wells with subsurface water levels were measured using an electric water level tape with measurements reported to within at least one tenth of a foot and typically to within a hundredth of a foot.

- Exceptions to this procedure included:

  - Domestic wells that could not be accessed at the well head or were behind a pressure tank (well numbers 7, 8, 13, 16, 18, 42).

  - Free-flowing wells that could not be sealed due to leaks caused by corrosion and age (wells 2, 635, 4002).

  - Free-flowing wells that could not be sealed due to poor valve fittings or cracked valves (well 696).

  - Free-flowing wells where existed the possibility of rupturing a line when pressurized due to age (well 7002).

  - Wells that contained pumps and pump tubing making it difficult to retrieve a water level tape (well 619).

- Water level measurements from pumping and monitoring wells that were taken during the aquifer tests are given in the aquifer test report (see Appendix 2.7-B).

Table 2.7-14: Well Data

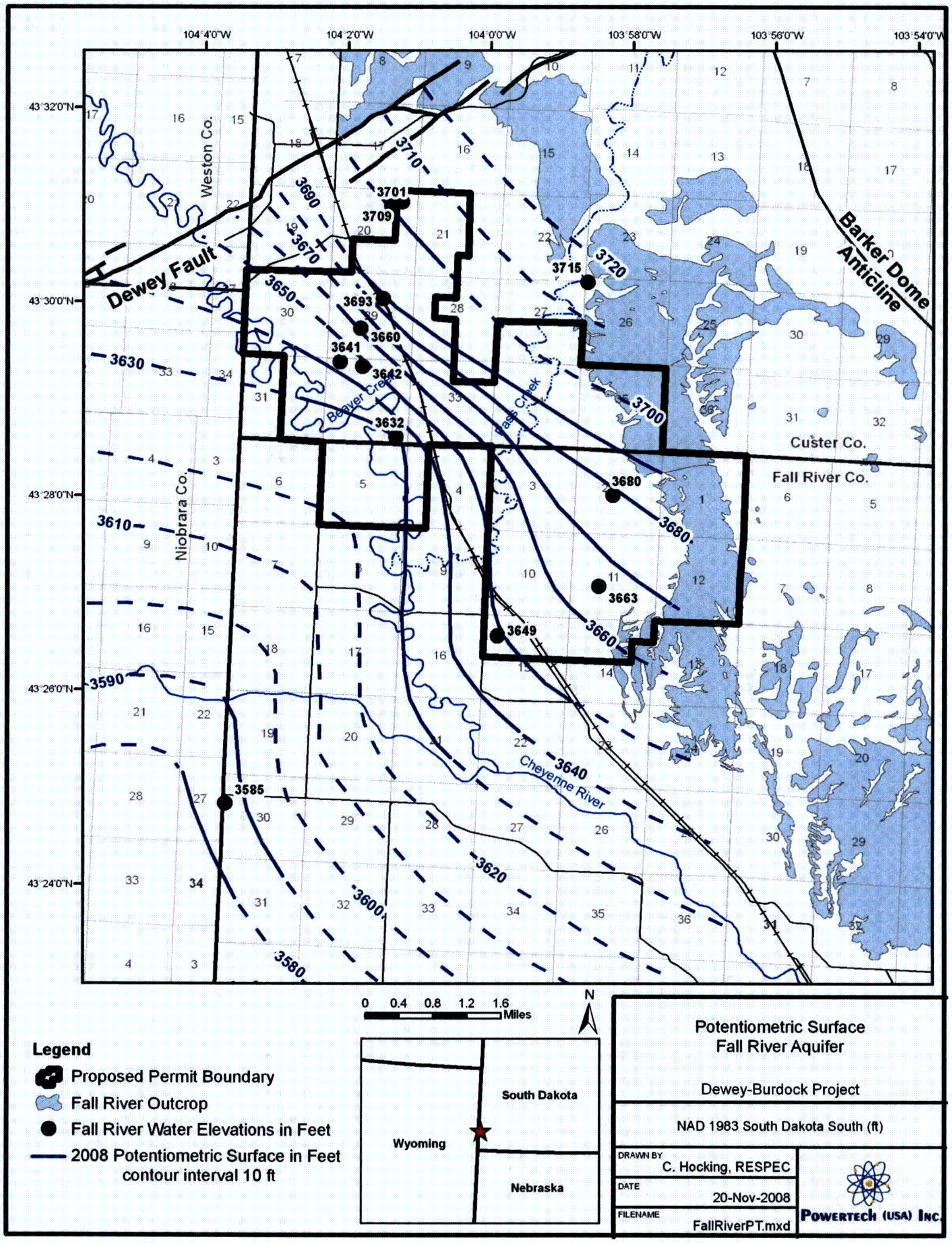
ID	SD State Plane 1983		Formation	Depth, ft	Screened interval, ft	Use
	East (ft)	North (ft)				
675	1015340.3	406352.2	Alluvium	14.4	4 - 14	Piezometer
676	999245.0	439891.6	Alluvium	22.5	12 - 22	Piezometer
677	991947.3	434035.9	Alluvium	14.5	4 - 14	Piezometer
678	995023.4	431834.9	Alluvium	14.5	4 - 14	Piezometer
679	1000303.0	446248.3	Alluvium	39	29 - 39	Piezometer
49	987330.6	444022.8	Fall River	600	unknown	Stock
607	980219.4	416377.6	Fall River	unknown	unknown	Piezometer
610	989998.0	447969.6	Fall River	680	630-672	Piezometer
613	990523.4	453775.8	Fall River	580	504-580	Piezometer
622	991174.5	454033.8	Fall River	520	503 - 580	Piezometer
631	1002575.7	449309.8	Fall River	80	30 - 80	Stock
681	988728.3	443725.3	Fall River	600	585 - 600	Pump Test Well
688	1003425.8	429974.4	Fall River	255	245 - 255	Piezometer
694	997116.1	426836.1	Fall River	392	377 - 392	Piezometer
695	990783.4	439312.5	Fall River	508	493 - 508	Piezometer
698	1004307.8	435651.1	Fall River	205	180 - 205	Piezometer
614	990583.8	453770.2	Fuson	620	609-620	Piezometer
12	995376.8	434378.5	Lakota	805	unknown	Stock
38	992726.9	442289.6	Lakota	494	unknown	Stock
608	980228.9	416454.6	Lakota	unknown	unknown	Piezometer
609	990133.3	447808.3	Lakota	1000	903-966	Piezometer
615	990571.0	453708.9	Lakota	800	712 - 800	Piezometer
619	1003106.9	437045.9	Lakota	280	unknown	Stock
650	1012180.5	433331.4	Lakota	unknown	unknown	Stock
680	1003476.6	429969.1	Lakota	436	426 - 436	Pump Test Well
689	988715.0	443789.2	Lakota	730	715 - 730	Piezometer
697	990748.4	439347.4	Lakota	682	667 - 682	Piezometer
3026	1012037.4	432833.2	Lakota	196	166 - 196	Stock
8002	1004651.5	418556.4	Lakota	500	unknown	Stock
628	990894.7	449719.2	Inyan Kara	unknown	unknown	Stock
668	999428.2	427450.3	Inyan Kara			
8003	1004520.9	418530.8	Inyan Kara	unknown	unknown	Garden

Maps of the current potentiometric surface for the Fall River (Figure 2.7-14), Lakota (Figure 2.7-15), and Unkpapa (Figure 2.7-16) aquifers have been generated using water level data collected in the area from September 2007 through June 2008 (Appendix 2.7-A). The regional USGS map *"Potentiometric Surface of the Inyan Kara Aquifer in the Black Hills Area,* *South Dakota"* was used as a general guide in areas where water level data are unavailable (Strobel et al., 2000).

The general pattern of groundwater flow is, as expected, away from the highlands and is similar for all aquifer local units. Throughout the southwestern Black Hills including the study area, the groundwater gradient is generally southwestward. Analyses of regional information indicate that similar flow patterns should exist from ground surface to the Precambrian aquifer.

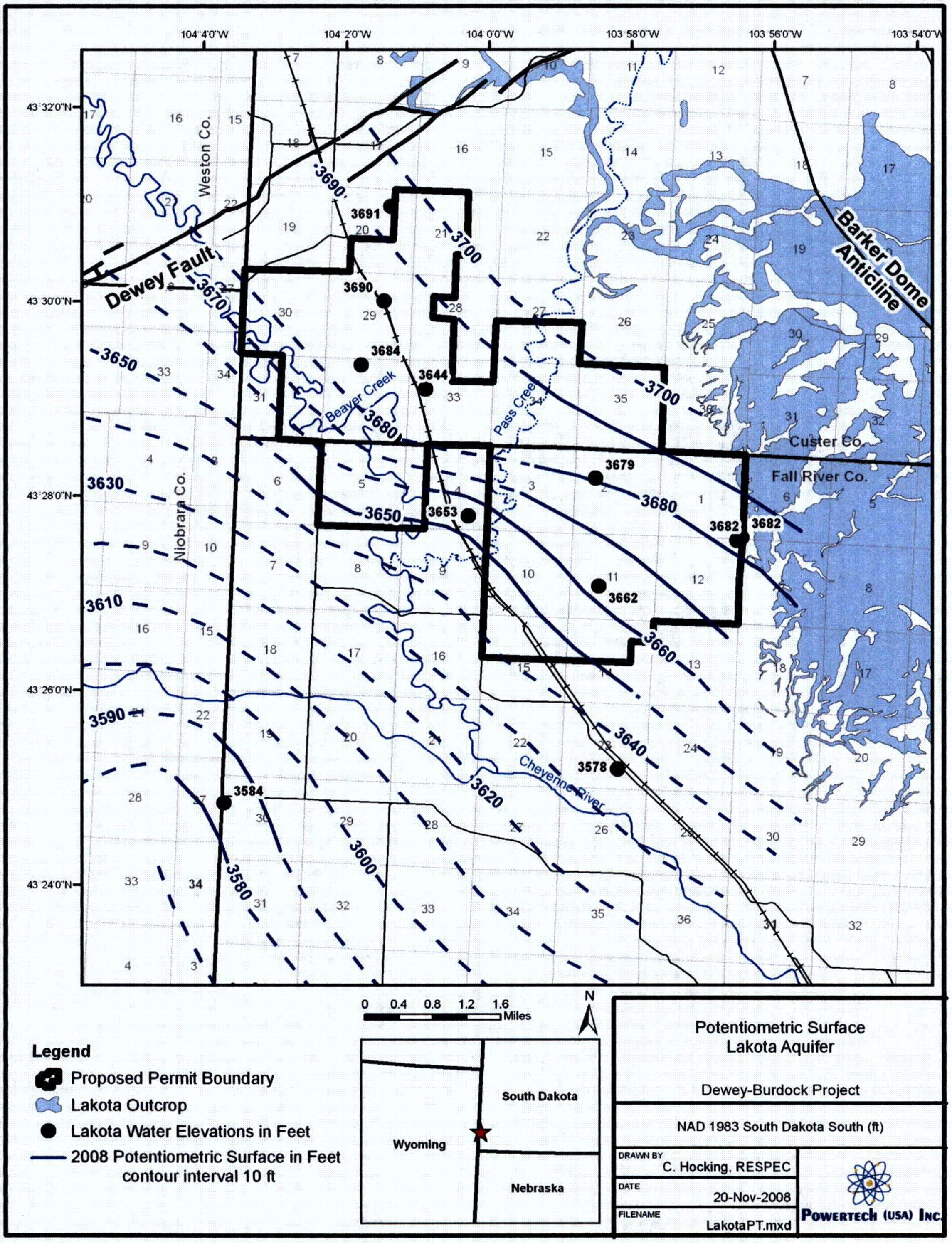
Appendix 2.7-A summarizes water levels and elevations measured in Fall River and Lakota wells. These paired wells, plus data gathered during the pumping tests, provide the capability to assess site-specific aquifer connections as follows:

- Analyses of water levels reported from wells near recharge or outcrop areas demonstrate that water levels in the Lakota Formation are somewhat higher than in the Fall River.
- With increasing distance from the recharge areas, this difference in head appears to diminish.
- Review of pumping test data from the Dewey area indicates that pumping a well located within the Fall River does not impact the Lakota heads. Where the Fuson is an ineffective confining unit, water could flow upward into the Fall River Formation. Because of this uncertain connectivity, the Fall River and Lakota Formations are considered to be one aquifer (the Inyan Kara aquifer) in this report.



Note: Potentiometric surface based on average water level values at the project site. Contours are dashed where approximate.

Figure 2.7-14: Potentiometric Surface of the Fall River Aquifer



Note: Potentiometric surface based on average water level values at the project site. Contours are dashed where approximate.

Figure 2.7-15: Potentiometric Surface of the Lakota Aquifer

Powertech (USA) Inc.

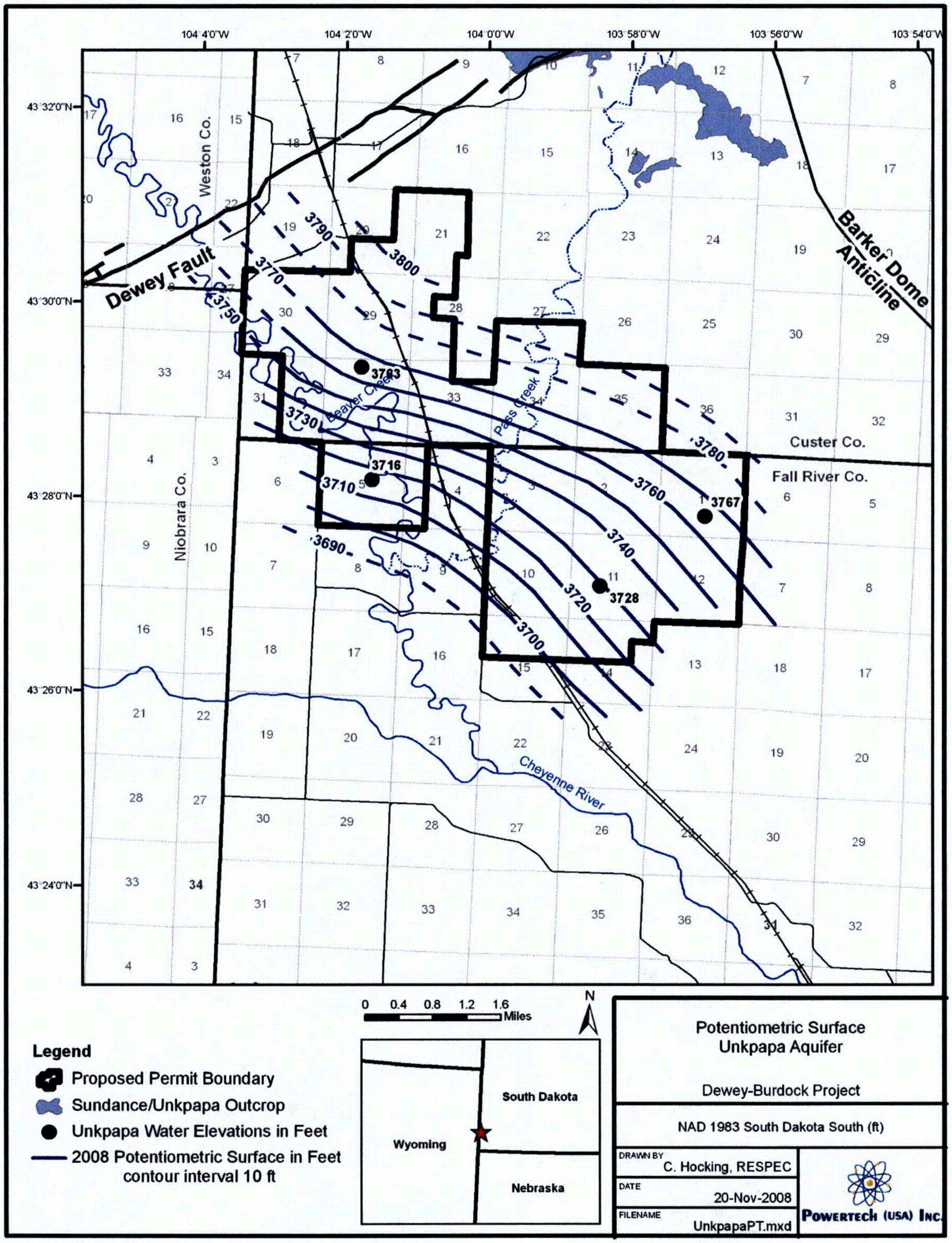


Figure 2.7-16: Potentiometric Surface of the Unkpapa Aquifer

If the aquifer materials were homogeneous, groundwater would flow in the direction of the gradient. Within the PAA, it is likely that groundwater flow is partially controlled by interfingering channels and heterogeneous beds.

North of the site, the Dewey Fault is believed to affect groundwater movement. At its greatest, the Dewey Fault has more than 400 feet of offset. This offset would place the Lakota Formation, south of the fault, against the impermeable Spearfish Formation north of the fault. Based on TVA's Dewey pumping test, the fault behaved as an impermeable zone and resulted in drawdown greater than would occur in an infinite aquifer (Boggs, 1983).

It is common practice in the area to allow artesian wells to continuously flow to prevent freezing. Undoubtedly, this practice has resulted in a decline in potentiometric head over decades.

2.7.2.2.9 Site Groundwater Recharge and Discharge

Groundwater may recharge or discharge from the site under the following mechanisms:

- Recharge via infiltration of precipitation
- Discharge via evapotranspiration
- Recharge or discharge to streams or springs
- Recharge or discharge into overlying or underlying hydrogeologic units
- Recharge or discharge along the Dewey fault zone
- Discharge to wells
- Recharging groundwater flow into the study area
- Discharging groundwater flow out of the study area.

The first three mechanisms are limited to unconfined alluvium in stream channels with depths less than 100 feet. The remaining mechanisms apply from the highland outcrop to the PAA, as the units transition from unconfined outcrops to confined units. Recharge to confined groundwater is primarily from precipitation recharge at the outcrop. Most of this recharge occurs at the highland outcrops, as shown in Figure 2.7-17. Based on data from Carter et al. (2001), an average of 0.3 to 0.5 inches of precipitation (2 to 3 percent of 16 in/yr) that falls each year recharges the Inyan Kara aquifer.

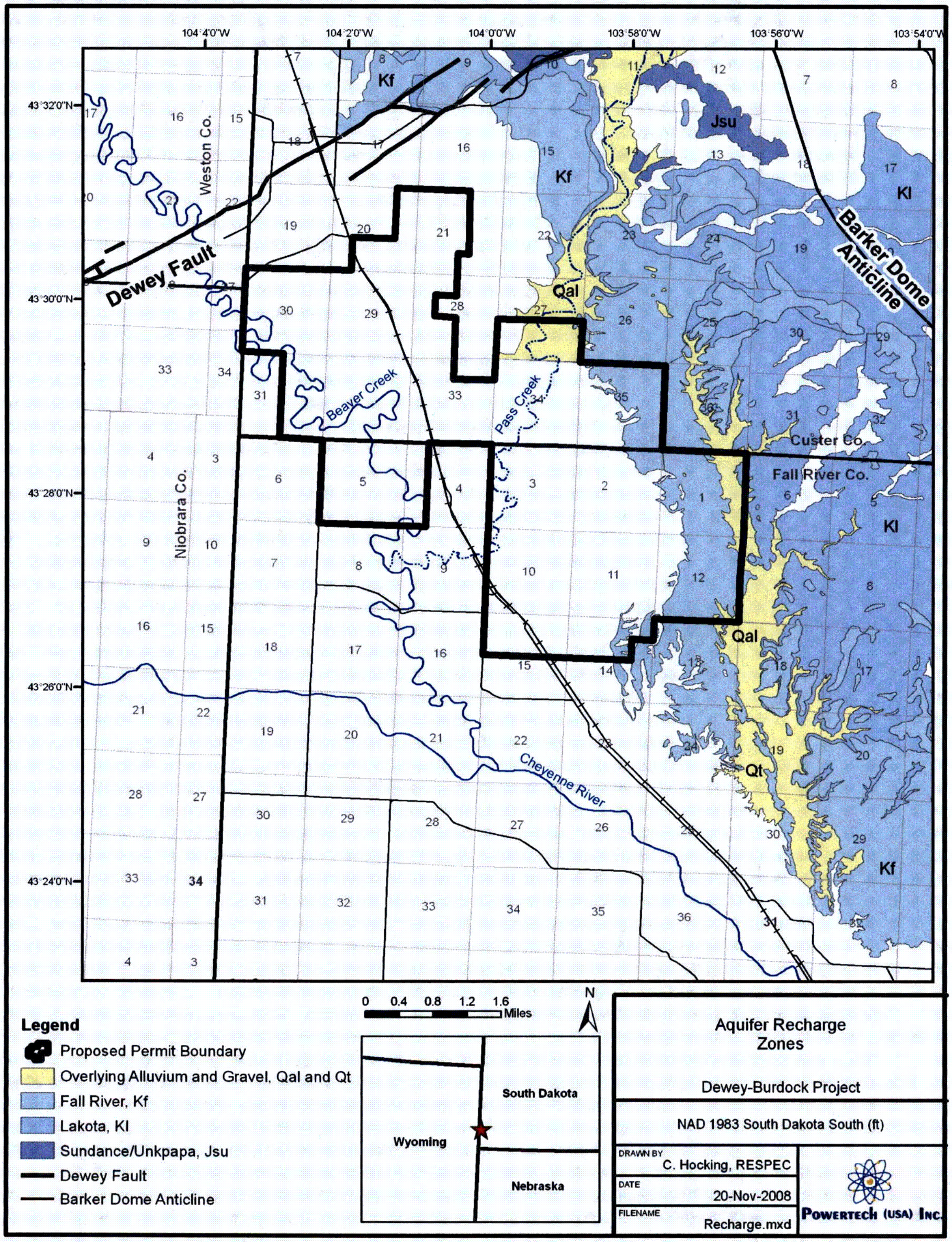


Figure 2.7-17: Aquifer Recharge Zones

2.7.2.2.10 Site-Specific Groundwater/Surface Water Interactions

Near the PAA, there are several possible modes of interaction between groundwater and surface water. Groundwater becomes surface water where free-flowing artesian wells discharge into surface water impoundments. There are no natural springs in the PAA. The only other major avenue for interchange is along the alluvium where Pass Creek crosses the Inyan Kara outcrop. Here, the alluvium may either gain or lose flow to the underlying aquifer. There is currently no stream loss data for Pass Creek to quantify this interaction.

2.7.2.2.11 Hydraulic Properties of the Inyan Kara at the Project Site

This section describes past and recent aquifer pumping tests and the insight on hydraulic properties that were gained.

2.7.2.2.12 Summary of Previous Pump 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 Statement (DES) 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 two miles north of the current PAA. 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.

2.7.2.2.12.1 Dewey Proposed Action Area

The Dewey test was conducted in 1982 northeast of Dewey Road at the location shown on Figure 2.7-18. The test consisted of pumping in the Lakota formation for 11 days at an average rate of 495 gallons per minute [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.

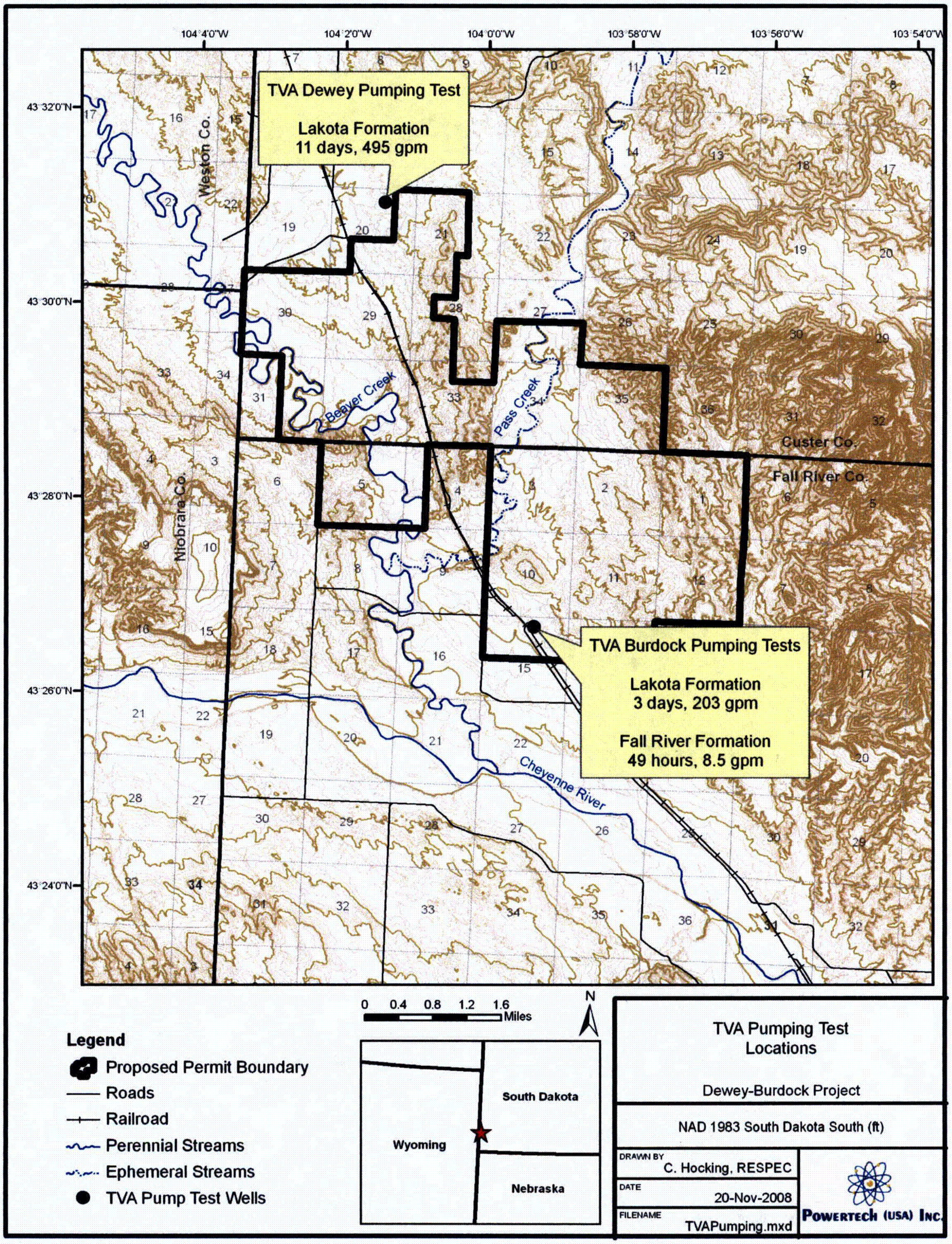


Figure 2.7-18: Location of Historical TVA Pumping Tests

2.7.2.2.12.2 Burdock Project Area

The Burdock tests were conducted in 1979 near Dewey Road at the location shown on Figure 2.7-18. 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}.

2.7.2.2.13 2008 Pumping Tests

In 2008 pumping tests were performed at both the project areas, along with laboratory tests on related core samples, to determine aquifer properties at the site. A work plan (Knight Piésold, 2008a) was prepared and distributed to interested representatives of state and federal agencies, including the South Dakota 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, 2008b), Appendix 2.7-B. The report results are briefly summarized in the following sections.

2.7.2.2.14 Burdock Project Area

2.7.2.2.14.1 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 2.7-15) ranged from 120 to 223 ft^2/day with the median value of 150 ft^2/day.
- Four storativity determinations (Table 2.7-15) ranged from 6.8×10^{-5} to 1.9×10^{-4} with the median value of 1.2×10^{-4}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 2,100 ft.
- 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 the USGS (Halford and Kuniansky, 2002) theoretical method.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 2.7-16) were made on sandstone layers similar to that tested in the pump test; measured horizontal hydraulic conductivity ranged from 5.9 to 9.1 ft/d, the mean value was 7.4 ft/d and the mean ratio of horizontal to vertical hydraulic conductivity in Burdock area sandstone was 2.47:1.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 2.7-16) were made on shale layers from 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 2.7×10^{-4} ft/d) 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/d).
- The range of hydraulic conductivities determinable from test transmissivities was 0.9 to 15.0 ft/d, 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.

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

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (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	-	-
11-15	Obs #1	243	Theis DD(1)	67	-	1.3E-03	-
			CJ Recovery (3)	100	<0.1	-	-
11-14C	Obs #2	250	Theis DD(1)	128	-	6.8E-05	-
			H-J DD(1)	120	-	6.9E-05	--
			Theis Recovery(1)	174	<0.01	-	-
			CJ Recovery (3)	160	<0.01	-	-
11-02	Obs #3	1,292	Theis DD(1)	223	-	1.9E-04	-
			H-J DD(1)	185	-	1.7E-04	-
			CJ Recovery (3)	260	<0.15	-	-
Upper Lakota Sandstone							
11-19	Obs	50	Theis DD(2)	260	-	1.0E-01	-
			CJ Recovery (3)	190	<0.15	-	-
Fall River (lower sandstone layer)							
11-17	Obs	50	Noordbergum Effect and response cannot be interpreted analytically				
Unkpapa Formation							
11-18	Obs	35	No response during pumping test.				-
Distance Drawdown (11-14C, 11-15, 11-02)(2)				145	<0.08	2.2E-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		1.8E-04	

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

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

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

(4) Summary values from p. 17 in Boggs and Jenkins (1980).

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

(a) storativity not valid at pumping well.

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

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

Table 2.7-16: Laboratory Core Analyses at Project Site

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

2.7.2.2.14.2 Burdock Pumping Test Conclusions

The Burdock pumping test in 2008 may be directly compared to the 1979 TVA test for the Lakota (Chilson) aquifer as the tests were nearly at the same location (Figure 2.7-18). The average transmissivity and storativity values determined from the TVA tests were 190 ft^2/d and 1.8×10^{-4} (see p. 17 in Boggs and Jenkins, 1980). Comparing median transmissivity of 150 ft^2/d and storativity of 1.2×10^{-4}determined in the 2008 test to the TVA test, the new aquifer parameters for the lower 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 transmissivity of 190 ft^2/d 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 ft/d over a thickness of 170 ft 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 ft/d 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, 2008b). 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 x 10^{-8} (2.7 x 10^{-4} ft/d) 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 pg. (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 startup 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 x 10^{-8} cm/sec (6 x 10^{-5} ft/d). Together with the pump test data, the core data indicate that the underlying Morrison formation and overlying Fuson member can serve as aquitards for ISL operations.

For the Lakota sandstone, the laboratory core data indicate an average horizontal hydraulic conductivity of 7 ft/d, and as high as 9.1 ft/d. Interpretation of the test results calculates that horizontal permeability may be as great as 15 ft/d 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 ft distance. This indicates the aquifer was stressed to produce good quality analytical results.

2.7.2.2.15 Dewey Project Area

2.7.2.2.15.1 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 2.7-17) ranged from 180 to 330 ft^2/day with the median value of 255 ft^2/day.
- Five storativity determinations (Table 2.7-17) ranged from 2.3×10^{-5} to 2.0×10^{-4} with the median value of 4.6×10^{-5}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 5,700 feet.
- 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 2.7-16) 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/d, and the ratio of horizontal to vertical hydraulic conductivity was 4.5:1.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 2.7-16) were made on shale samples from the two major confining units overlying and underlying the pump test area with the following results:
  - Skull Creek shale: laboratory core data for the shale sample from the overlying Skull Creek formation indicate a vertical permeability of 5.4×10^{-9} cm/sec (1.5×10^{-5} ft/d).
  - 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/d).

2.7.2.2.15.2 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 2.7.2.2.14.1), 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, 2008b).

- Response at the stock tank well (GW-49at 1,400 ft 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 ft 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, 2008b), 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.

POWERTECH (USA) INC.

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

Dewey Test Site Pumping Test Interpretations							
	Well	Radial Dist.	Interpretation	Transmissivity	u or u'	Storativity	Note
Well I.D.	Type	(ft)	Method	(ft^2/day)	(unitless)	(unitless)	
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	-	3.3E-05	--
			Theis Recovery(1)	260	<0.01	-	-
			CJ Recovery(3)	280	<0.01	-	-
32-4C	Obs #2	467	Theis DD(1)	333	-	5.6E-05	-
			CJ Recovery (3)	120(a)	<0.01	-	
29-7	Obs #3	2,400	Theis DD(2)	178	-	2.0E-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	-	2.3E-05	-
			CJ Recovery (3)	110	<0.05	-	-
Upper Fall River Sandstone							
32-9C	Obs	41	Theis DD(1)	217	-	1.6E-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	4.6E-05	r^2 = 0.78 (4 point line)
Pumping Well Efficiency = 93% to 95%							
							-
Summary:	Median			255		4.60E-05	
Average/Geometric Mean(4)				251		5.23E-05	

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

(1) Calculated by automated curve fitting in AquiferWin32™ software (ESI, 2003).
(2) Knight Piésold spreadsheet after methods in Driscoll (1986).
(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).
(4) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.
(a) only slope satisfying u 'criterion occurs after intersection with barrier boundary.
(b) not accepted due to anomalous response at well, see text.

Vertical flow 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, 2008b). 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.

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 an aquitard or aquiclude.

Hydraulic flow 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 feet head difference. The laboratory core data indicate a very low vertical permeability of 6.2×10^{-9} cm/sec (1.8×10^{-5} ft/d) 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/d), also appropriate for an aquitard or aquiclude.

For the Fall River sandstone, the laboratory core data indicate a horizontal hydraulic conductivity of 6.1 ft/d, and interpretation of the test results calculates that horizontal permeability may be as great as 17 ft/d 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 feet distance. This indicates the aquifer was stressed to produce good quality analytical results.

2.7.2.2.16 Hydraulic Connection of Aquifers at the Project Site

Regionally, the Inyan Kara is a confined aquifer. At the project site, the Graneros Group shale serves as the overlying confining unit that prevents upward migration. There are also no major aquifers above the Inyan Kara from which connection could occur. Below the Inyan Kara, the Morrison Formation serves as a relatively impermeable confining unit. At the project site, results from recent pump tests show that the Morrison effectively confines the Unkpapa aquifer below since no measurable drawdown in the Unkpapa was observed while pumping in the Inyan Kara. However, a minor amount of communication between the Inyan Kara and underlying aquifers (including the Unkpapa, Sundance, and Minnelusa) may occur in yet undiscovered areas where the Morrison is thin or absent or along undiscovered breccia pipes. For a more detailed discussion on the regional and site hydrostratigraphic units see Sections 2.7.2.1.1 and 2.7.2.2.1.

Within the Inyan Kara, the Fuson member of the Lakota is expected to be an effective interaquifer confining unit. Results of aquifer tests at the project site indicate that the Fuson Shale is not an effective barrier in some locations (Boggs and Jenkins, 1980). Locally unidentified structural features or more likely old, unplugged exploration holes enhance this interaquifer connection. The exact location of these potentially unplugged holes is undeterminable. However, over 95 percent of exploration holes never penetrated deeper than the lower Lakota and upper Morrison, so this potential venue of connection is limited to within the Inyan Kara itself. Flow from these open holes could potentially reach the ground surface, although swelling of overlying clays and associated collapse are probably preventing this situation from occurring. Because of such interaquifer connection, the Inyan Kara is treated in this report as one aquifer with the Fall River and Lakota representing sub-aquifers.

2.7.2.2.17 Groundwater Use

The following sections describe the regional, site, and operational water use in the PAA.

2.7.2.2.18 Regional Groundwater Use

The PAA is located at the southwestern edge of the Black Hills. The major aquifers of the Black Hills are the Precambrian, Deadwood, Madison, Minnelusa, and Inyan Kara (see Section 2.7.2.1.1). Within Fall River and Custer Counties, each of these aquifers is used, with wells generally being drilled into the next underlying aquifer below the surface. There is no public data available to quantify the use from each of these aquifers within Fall River or Custer County.

2.7.2.2.19 Operational Water Use

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

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

2.7.2.2.20 Water Requirements for the Proposed Action Facilities

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

2.7.2.2.21 Water Usage with Reverse Osmosis and without Reverse Osmosis

Total net water use for production operations (as wellfield purge) will be in the range 20-120 gpm from the Inyan Kara. Each production site will consume between 10 and 60 gpm as well field purge. During restoration operations, water consumption will be greater from the Inyan Kara. However, net withdrawal from the Inyan Kara formation will also remain at the range of 0.5 to 3 percent of total restoration flow during groundwater treatment via RO method of restoration (Table 2.7-18). It is expected that the restoration activities will also be split between the two sites. Net withdrawal during these restoration operations (as well field purge) is expected to be a total of 2.5 to 15 gpm from the Inyan Kara. At each site, Dewey and Burdock, 1.25 to 7.5 gpm will be the net withdrawal during restoration operations. Net water usage from the Maddison using a (RO) unit to restore groundwater following production, approximately 167 gpm of the 500 gpm (without RO utilization; Table 2.7-19), will need to be made up with Madison aquifer water.

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

Madison formation

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

Inyan Kara formation

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

The actual net difference between fluid produced and fluid injected must be maintained at a rate equivalent to the 0.5-3 percent bleed rates described above. With RO process used for treating well field bleed streams, permeate will be reinjected and will substantially lower the requirement for makeup waterfrom the Madison; such use of RO typically reduces make-up water requirements to approximately 1/3 of the water that would be required without RO (Table 2.7-19).

Table 2.7-18: Net Water Usage with Reverse Osmosis

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

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

Table 2.7-19: Net Water Usage without Reverse Osmosis

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

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

2.7.3 Site Baseline Water Quality

2.7.3.1 Surface Water Quality

In compliance with NRC Guide 4.14 (RG 4.14), NUREG-1569, and South Dakota mining rules ARSD 74:29, the perennial and ephemeral streams and impoundments in the PAA were sampled upstream and downstream of the proposed permit boundary. Table 2.7-20 lists stream and impoundment water quality sampling sites within and adjacent to the PAA. Plate 2.5-1 shows the locations of the stream and impoundment sampling sites.

Table 2.7-20: Surface Water Quality Sampling Sites

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

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

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

- Two sites on Beaver Creek (BVC01 and BVC04).

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

Surface water impoundments were evaluated for additional sampling and included stock dams and mine pits. Surface water impoundments were originally identified on topographic maps and aerial photographs. Subsequently a field survey was completed in July 2007 to fully identify and gather impoundment-location data. A total of 48 impoundments were verified, photographed, and described as summarized in Table 2.7-21.

Table 2.7-21: All Identified Impoundments

ID	SD State Plane 1983		Type	Groundwater Influence
	East (ft)	North (ft)		
Sub01	998654	446816	stock pond	
Sub02	1001071	443526	Triangle Mine Pit	x
Sub03	1005005	438448	mine dam	
Sub04	1002542	437518	stock pond	
Sub05	1004591	437191	mine dam	
Sub06	1006665	437019	Darrow Mine pit - Northwest	x
Sub07	1009312	434360	stock pond	
Sub08	1004195	427057	stock pond	x
Sub09	1004640	427089	stock pond	
Sub10	1005961	421367	stock pond	
Sub11	1009659	432225	stock pond	
Sub20	1002532	428038	stock pond	
Sub21	1000370	429024	stock pond	
Sub22	999992	427168	stock pond	
Sub23	999717	426319	stock pond	x
Sub24	1000794	423427	stock pond	x
Sub25	999224	422605	stock pond	
Sub26	1000307	420428	stock pond	
Sub27	1003423	419002	stock pond	
Sub28	1004298	422820	stock pond	
Sub29	1002964	442601	stock pond	
Sub30	1007163	430087	stock pond	
Sub31	1004019	431822	stock pond	
Sub32	1007073	429705	stock pond	
Sub33	1005797	429469	stock pond	
Sub34	1003123	433891	stock pond	

ID	SD State Plane 1983		Type	Groundwater Influence
	East (ft)	North (ft)		
Sub35	999672	432197	stock pond	
Sub36	987313	442298	stock pond	
Sub37	987290	441389	stock pond	
Sub38	995337	434148	stock pond	
Sub39	996815	438345	stock pond	
Sub40	1008631	433781	Darrow Mine pit - Southeast	
Sub41	997783	439460	stock pond	
Sub42	989530	435506	stock pond	
Sub43	1010029	437824	stock pond	
Sub44	998462	429397	stock pond	
Sub45	994820	423587	stock pond	x
Sub46	1008898	438460	stock pond	
Sub47	1009398	439185	stock pond	
Sub48	980447	421586	stock pond	

Because of the number of impoundments, their relatively small drainage basin, and the tendency of many to be dry after substantial rainfall, sampling a representative subset of the water impoundments was proposed. Impoundments were selected based on the presence of water, drainage area, and location. Eleven surface water impoundments were selected to construct a representative sampling group for the PAA.

2.7.3.1.1 Sample Collection and Analysis Methods

A surface water quality sample constituent list was developed based on NUREG-1569 groundwater parameters (minus radon), NRC 4.14 parameters, and added parameters from a constituent-list review with South Dakota DENR. NUREG-1569 gives no specific requirements for sampling constituents of surface water bodies. Table 2.7-21 lists constituents analyzed for in surface water samples, the number of samples of each collected, the analytical method, and the Practical Quantitation Limit (PQL) for each constituent.

The following methodology was applied to collection of surface water samples:

- Field methods for sampling surface waters followed South Dakota Department of Environment and Natural Resources *Standard Operating Procedures for Field Samplers, Volume I* (SDDENR, 2003).
  - Field methods included measuring and recording field water-quality parameters dissolved oxygen, turbidity, pH, specific conductivity, and temperature with a water-quality probe.

- Sample bottles and preservative were supplied by EPA-certified Energy Laboratories in Rapid City and rinsed three times with sample water before sample collection and labeled with site ID, date, and time. Bacteriological sample bottles were not rinsed prior to filling.

- Samples were field-preserved (where required) and immediately placed on ice then delivered within 24 hours to Energy Laboratories in Rapid City along with proper chain-of-custody forms.

- A replicate and a blank sample were collected for every 10 water quality samples collected.

• Sites on Beaver Creek and Pass Creek were visited monthly and sampled when water was present.

• Although it does not pass through the permit boundary, the Cheyenne River was also sampled monthly upstream and downstream of confluences with streams passing through the permit boundary.

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

Table 2.7-22 Number of Surface Water Samples Collected, Analytical Method, and PQL by Constituent

Constituent, Unit	Number of Samples Analyzed	Analytical Method	PQL[1]
Microbiological			
Bacteria, Fecal Coliform (cfu/100ml)	81	A9222 D	2
Major Anions and Cations			
Anions (meq/L)	81	A1030 E	
Bicarbonate as HCO3 (mg/L)	81	A2320 B	5
Carbonate as CO3 (mg/L)	81	A2320 B	5
Sulfate (mg/L)	81	E300.0	36
Chloride (mg/L)	82	E300.0	1
Fluoride (mg/L)	81	E300.0	0.1
Nitrogen, Nitrate as N (mg/L)	81	E300.0	0.1
Cations (meq/L)	81	A1030 E	
Ammonia as N (mg/L)	61	A4500-NH3 G	1
Sodium-Dissolved (mg/L)	66	E200.7	0.8
Calcium-Dissolved (mg/L)	66	E200.7	0.5
Magnesium-Dissolved (mg/L)	66	E200.7	0.5
Potassium-Dissolved (mg/L)	66	E200.7	0.5
Silica-Dissolved (mg/L)	66	E200.7	0.5
General Water Quality Indicators			
Alkalinity-Total as CaCO3 (mg/L)	81	A2320 B	5
Anion/Cation Balance (± 5) (%)	81	A1030 E	
Conductivity @ 25 C (umhos/cm)	81	A2510 B	5
pH	81	A4500-H B	0.01
Sodium Adsorption Ratio (meq/L)	61	calculated	0.1
Solids-Total Dissolved TDS (mg/L)	81	A2540 C	5
Solids-Total Dissolved, Calc. (mg/L)	81	A1030 E	5
TDS Balance (0.80 - 1.20) (dec.%)	81	A1030 E	
Solids-Suspended Sediment SSC (mg/L)	81	D3977	5
Solids-Total Suspended TSS (mg/L)	81	A2540 D	5
Metals, Dissolved			
Aluminum-Dissolved (mg/L)www.	66	E200.7	0.1
Arsenic-Dissolved (mg/L)	66	E200.8	0.001
Barium-Dissolved (mg/L)	66	E200.7	0.1
Boron-Dissolved (mg/L)	66	E200.7	0.1
Cadmium-Dissolved (mg/L)	66	E200.8	0.005
Chromium-Dissolved (mg/L)	66	E200.7	0.05
Copper-Dissolved (mg/L)	66	E200.8	0.01
Iron-Dissolved (mg/L)	66	E200.7	0.03
Lead-Dissolved (mg/L)	66	E200.8	0.001
Manganese-Dissolved (mg/L)	66	E200.7	0.01
Mercury-Dissolved (mg/L)	66	E200.8	0.001
Molybdenum-Dissolved (mg/L)	66	E200.7	0.1

Constituent, Unit	Number of Samples Analyzed	Analytical Method	PQL[1]
Nickel-Dissolved (mg/L)	66	E200.7	0.05
Selenium-Dissolved (mg/L)	66	A3114 B	0.001
Selenium-IV-Dissolved (mg/L)	61	A3114 B	0.001
Selenium-VI-Dissolved (mg/L)	61	A3114 B	0.001
Silver-Dissolved (mg/L)	66	E200.8	0.005
Thorium 232-Dissolved (mg/L)	66	E200.8	0.005
Uranium-Dissolved (mg/L)	70	E200.8	0.003
Vanadium-Dissolved (mg/L)	66	E200.7	0.1
Zinc-Dissolved (mg/L)	66	E200.7	0.01
Metals, Suspended			
Thorium 232-Suspended (mg/L)	81	E200.8	0.001
Uranium-Suspended (mg/L)	81	E200.8	0.0003
Metals, Total			
Aluminum-Total (mg/L)	66	E200.7	0.1
Arsenic-Total (mg/L)	81	E200.8	0.001
Barium-Total (mg/L)	81	E200.7	0.1
Boron-Total (mg/L)	81	E200.7	0.2
Cadmium-Total (mg/L)	81	E200.8	0.005
Calcium-Total (mg/L)	57	E200.7	1
Chromium-Total (mg/L)	81	E200.7	0.05
Chromium-Hexavalent (mg/L)	66	A3500-Cr B	
Chromium-Trivalent (mg/L)	66	calculated	0.01
Copper-Total (mg/L)	81	E200.7	0.01
Iron-Total (mg/L)	81	E200.7	0.03
Lead-Total (mg/L)	81	E200.8	0.001
Magnesium-Total (mg/L)	57	E200.7	0.5
Manganese-Total (mg/L)	81	E200.7	0.01
Mercury-Total (mg/L)	91	E245.1	0.001
Molybdenum-Total (mg/L)	81	E200.7	0.1
Nickel-Total (mg/L)	81	E200.7	0.05
Potassium-Total (mg/L)	57	E200.7	0.5
Selenium-Total (mg/L)	81	A3114 B	0.002
Selenium-IV-Total (mg/L)	66	A3114 B	0.001
Selenium-VI-Total (mg/L)	66	A3114 B	0.001
Silica-Total (mg/L)	57	E200.7	0.5
Silver-Total (mg/L)	81	E200.8	0.005
Sodium-Total (mg/L)	57	E200.7	0.5
Thorium 232-Total (mg/L)	73	E200.8	0.005
Uranium-Total (mg/L)	81	E200.8	0.0003
Vanadium-Total (mg/L)	81	E200.7	0.1
Zinc-Total (mg/L)	81	E200.7	0.01

Constituent, Unit	Number of Samples Analyzed	Analytical Method	PQL[1]
Radionuclides			
Lead 210-Dissolved (pCi/L)	46	E909.0M	1
Lead 210-Suspended (pCi/L)	46	E909.0M	1
Lead 210-Total (pCi/L)	37	E909.0M	1
Polonium 210-Dissolved (pCi/L)	46	RMO-3008	1
Polonium 210-Suspended (pCi/L)	46	RMO-3008	1
Polonium 210-Total (pCi/L)	37	RMO-3008	1
Radium 226-Dissolved (pCi/L)	63	E903.0	0.2
Radium 226-Suspended (pCi/L)	70	E903.0	0.2
Radium 226-Total (pCi/L)	73	E903.0	0.2
Thorium 230-Dissolved (pCi/L)	70	E907.0	0.2
Thorium 230-Suspended (pCi/L)	70	E907.0	0.2
Thorium 230-Total (pCi/L)	61	E907.0	0.2
Gross Alpha-Total (pCi/L)	81	E900.0	1
Gross Beta-Total (pCi/L)	81	E900.0	2
Gross Gamma-Total (pCi/L)	66	E901.1	20

[1]PQL = Practical Quantitation Limit. The concentration that can be reliably measured within specified limits during routine laboratory operating conditions, below which results are reported as "less than reporting limit". The contracting laboratory uses the PQL as the reporting limit.

2.7.3.1.2 Results

Tables 2.7-22, 2.7-23, 2.7-24, and 2.7-25 give results and statistical summaries for field water quality parameters collected at the Beaver Creek and Cheyenne River sites. Months without data indicate either a completely frozen stream or absence of water. Other surface-water-quality sites do not have enough data to justify running statistical analyses on measurements.

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

(3 of 21) of measurements and exceeded the irrigation daily-maximum standard of 4,375 umhos/cm in 48 percent (10 of 21) of measurements.

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

Table 2.7-23: Field Data and Statistics for BVC01

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

Table 2.7-24: Field Data and Statistics for BVC04

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

Table 2.7-25: Field Data and Statistics for CHR01

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

Table 2.7-26: Field Data and Statistics for CHR05

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

Appendix 2.7-C provides statistics for all surface water constituents detected at or above PQL by constituent. Appendix 2.7-D provides the minimum and maximum result for all sampled constituents detected at or above the PQL, the sampled site and the date of sampling. Appendix 2.7-E provides a comparison between water quality constituents in impoundments and streams that were detected at or above the PQL. Constituents in italics are those in which the absolute difference in percent detections between streams and impoundments was 30 percent or greater. Fecal coliform, alkalinity, bicarbonate, and dissolved and total boron were detected primarily in streams, while ammonia, dissolved aluminum, dissolved iron, dissolved nickel, dissolved and total zinc, and dissolved and total radium 226 were primarily detected in subimpoundments Appendix 2.7-F provides tabular results for all samples.

2.7.3.2 Groundwater Quality

This section provides details on the monitoring network, methods, and results for the baseline water quality sampling plan.

2.7.3.2.1 Groundwater Monitoring Network and Parameters

Baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980) as appropriate to ISL operations. Because of the significant number of groundwater wells, their geochemical similarities, and an abundance of historical water quality data, a representative subset of the wells was selected for sampling. The wells were selected based on type of use, aquifer, and location in relation to the ore bodies. For the baseline study for the NRC permit, 19 groundwater wells (14 existing and five newly drilled) were selected in response to an NRC suggestion to characterize point of contact water quality and water within overlying, production, and underlying aquifers (Figure 2.7-19, Table 2.7-26). The existing wells selected for sampling include eight domestic wells and six stock watering wells. The subset includes wells within the Fall River Formation (4), Lakota Formation (7), Inyan Kara Group (Fall River or Lakota) (2), Sundance Formation (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from July 2007 through June 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 12 wells will be sampled monthly beginning in March 2008 and continuing through February 2009 (Figure 2.7-20, Table 2.7-27). Of these 12 wells, six wells are in the Dewey area and six wells are near Burdock. At Dewey, there is a set of Fall River and Lakota wells sampled at three places, upgradient, within, and downgradient of the proposed operations. Near the Burdock area, the same well arrangement applies with two wells upgradient, within, and downgradient of the proposed operations. Data for parameters available to date are presented in this section. In addition to the baseline sampling plan, one water quality sample was collected from each of the monitor wells used during the May 2008 aquifer pump tests (Table 2.7-28).

POWERTECH (USA) INC.

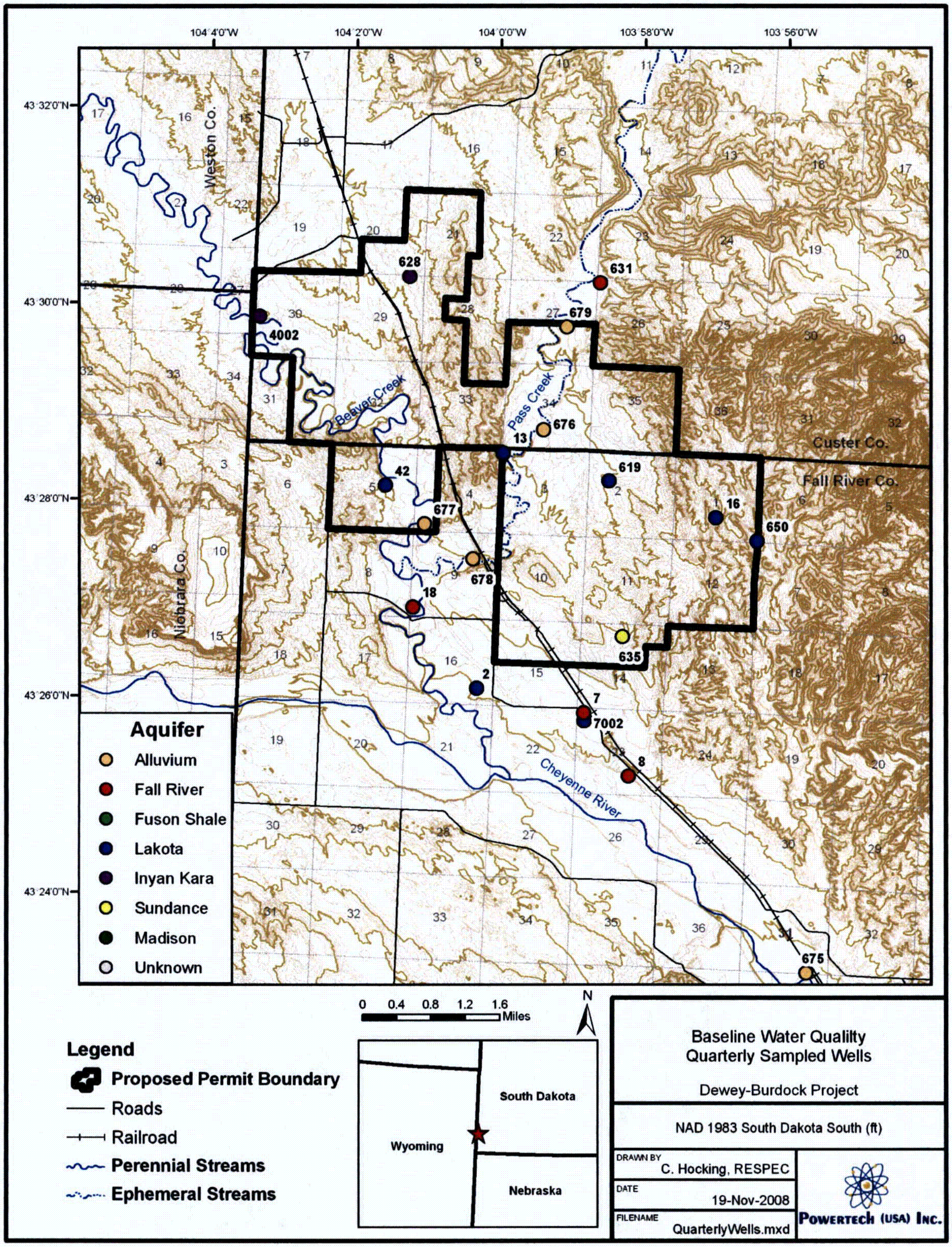


Figure 2.7-19: Baseline Groundwater Quality Quarterly Sampled Wells

POWERTECH (USA) INC.

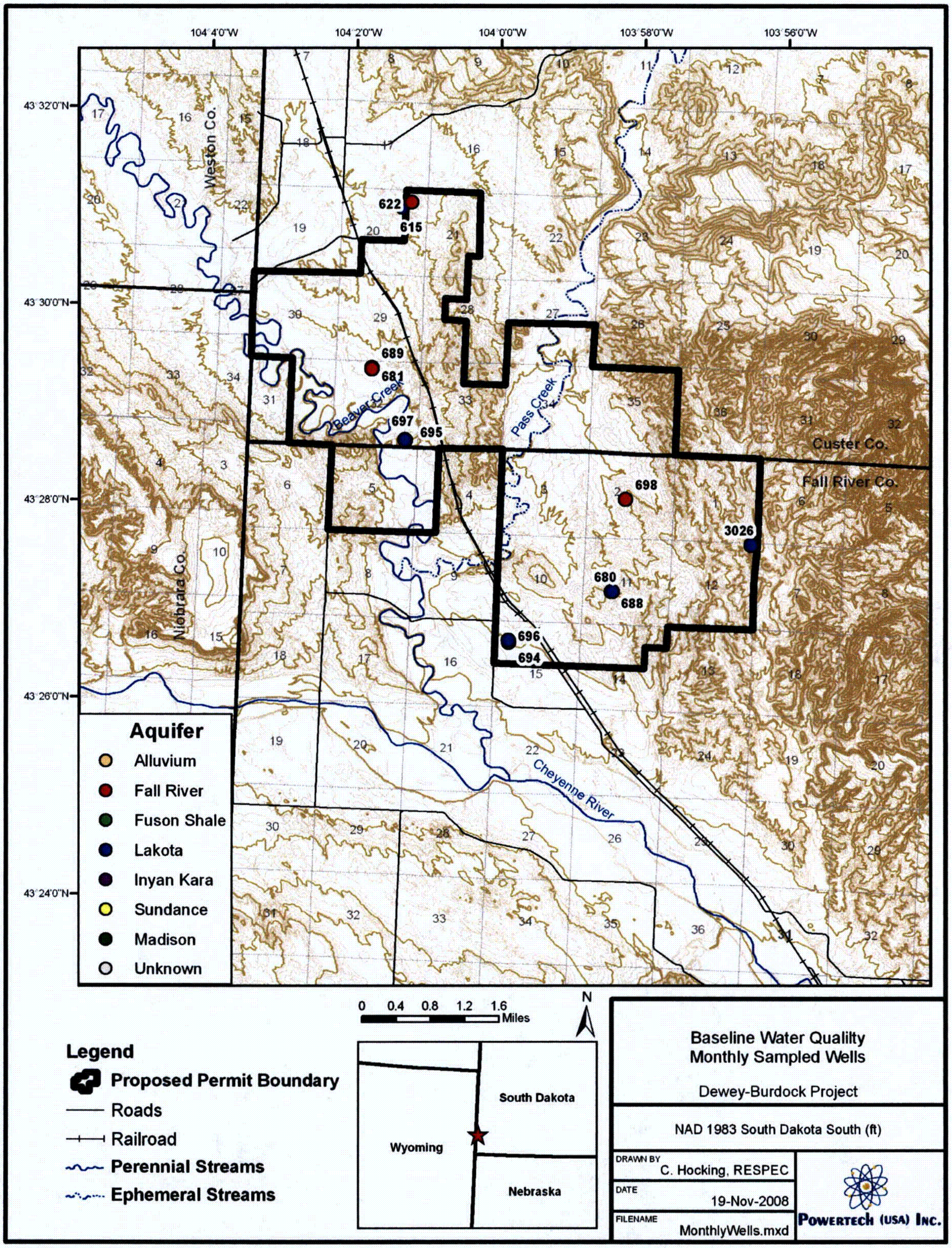


Figure 2.7-20: Baseline Groundwater Quality Monthly Sampled Wells

Table 2.7-27: Quarterly Sampled Groundwater Quality Well Data

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

Table 2.7-28: Monthly Sampled Groundwater Quality Well Data

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

Table 2.7-29: Additional Well Data

ID	SD State Plane 1983 East (ft)	SD State Plane 1983 North (ft)	Formation	Depth, ft	Screened Interval, ft	Use	Purpose
49	987330.6	444022.8	Fall River	600	unknown	Stock	supplemental
682	1003535.5	431259.6	Lakota	460	450-460	Piezometer	supplemental
683	988607.9	446108.0	Fall River	650	635-650	Piezometer	supplemental
684	1003586.9	429745.8	Lakota	423	413-423	Piezometer	supplemental
685	989085.5	443415.4	Fall River	595	580-595	Piezometer	supplemental
686	1003365.4	429751.8	Lakota	428	418-428	Piezometer	supplemental
687	988476.4	443730.6	Fall River	608	590-605	Piezometer	supplemental
691	988764.8	443706.9	Fall River	505	490-505	Piezometer	supplemental
692	1003466.9	429999.5	Lakota	335	325-335	Piezometer	supplemental

Figure 2.7-21 shows the wells that are upgradient, near and downgradient of the proposed production areas at the site. Results of these samples were included in the statistical analyses.

A groundwater quality constituent list was developed based on NUREG-1569 groundwater parameters, NRC 4.14 parameters, and added parameters from a constituent-list review with South Dakota DENR. Table 2.7-29 lists constituents analyzed for in groundwater samples, the number of samples analyzed for each constituent, the analytical method, and the Practical Quantitation Limit (PQL).

POWERTECH (USA) INC.

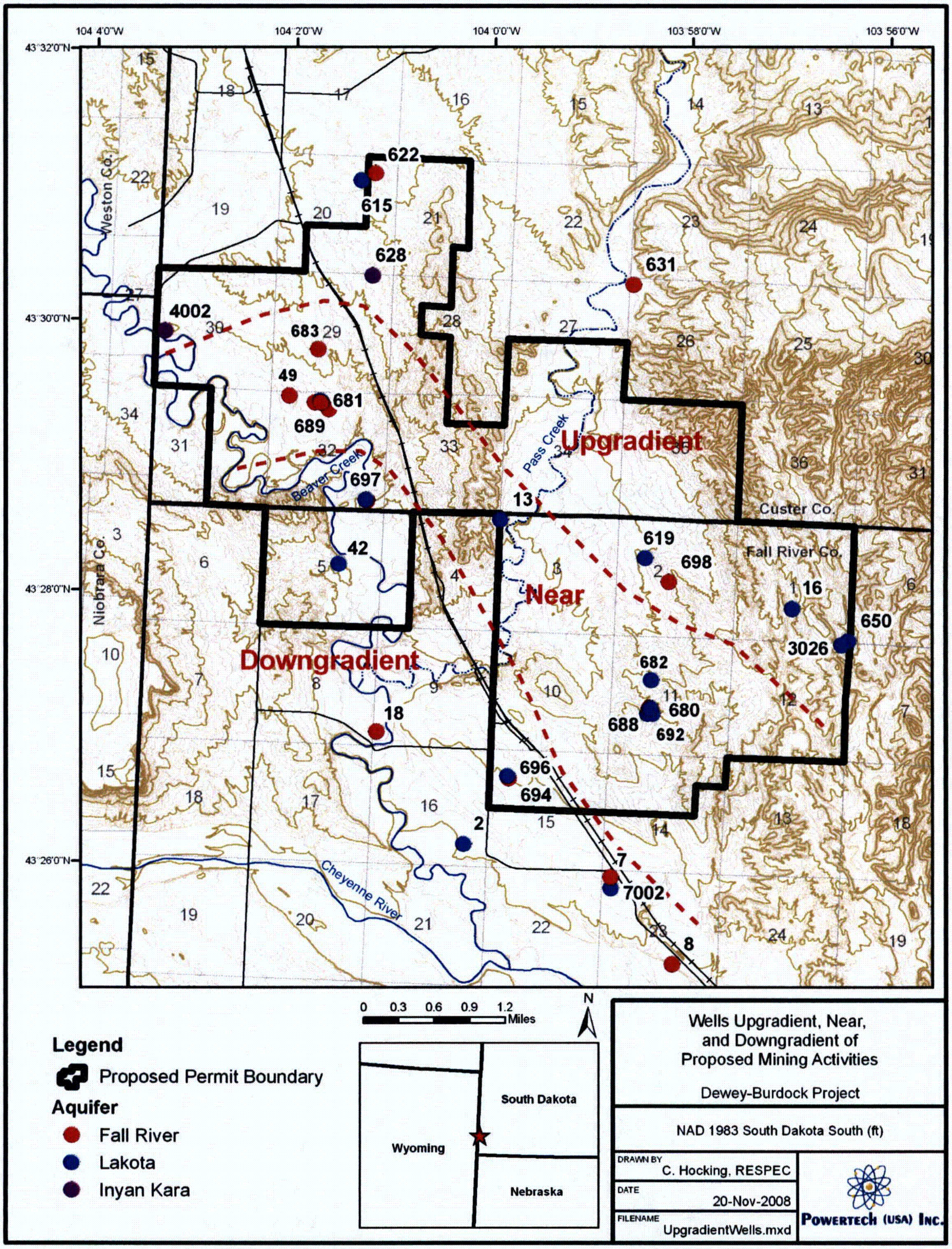


Figure 2.7-21: Wells Upgradient, Near, and Downgradient of Proposed Mining Activities

Table 2.7-30: Number of Groundwater Samples Collected, Analytical Method, and PQL by Constituent

Constituent, Unit	Number of samples analyzed	Analytical Method	PQL[1]
Major Cations and Anions			
Anions (meq/L)	140	A1030 E	
Bicarbonate as HCO3 (mg/L)	140	A2320 B	5
Carbonate as CO3 (mg/L)	140	A2320 B	5
Sulfate (mg/L)	140	E300.0	36
Chloride (mg/L)	140	E300.0	1
Fluoride (mg/L)	140	E300.0	0.1
Nitrogen, Nitrite as N (mg/L)	140	E300.0	0.1
Nitrogen, Nitrate as N (mg/L)	140	E300.0	0.1
Cations (meq/L)	140	A1030 E	
Ammonia (mg/L)	140	A4500-NH3 G	1
Sodium-Dissolved (mg/L)	140	E200.7	0.8
Calcium-Dissolved (mg/L)	140	E200.7	0.5
Magnesium-Dissolved (mg/L)	140	E200.7	0.5
Potassium-Dissolved (mg/L)	140	E200.7	0.5
Silica-Dissolved (mg/L)	140	E200.7	0.5
General Water Quality Indicators			
Alkalinity-Total as CaCO3 (mg/L)	140	A2320 B	5
Anion/Cation Balance (± 5) (%)	280	A1030 E	
Conductivity @ 25 C (umhos/cm)	140	A2510 B	5
Oxidation-Reduction Potential (mV)	118	A2580 B	
pH	140	A4500-H B	0.01
Sodium Adsorption Ratio (meq/L)	120	Calculation	0.1
Solids-Total Dissolved TDS (mg/L)	140	A2540 C	5
Solids-Total Dissolved, Calc. (mg/L)	140	Calculation	5
TDS Balance (0.80 - 1.20) (dec.%)	140	A1030 E	
Metals, Dissolved			
Aluminum-Dissolved (mg/L)	140	E200.8	0.1
Arsenic-Dissolved (mg/L)	140	E200.8	0.001
Barium-Dissolved (mg/L)	140	E200.8	0.1
Boron-Dissolved (mg/L)	140	E200.7	0.1
Cadmium-Dissolved (mg/L)	140	E200.8	0.005
Chromium-Dissolved (mg/L)	140	E200.8	0.05
Copper-Dissolved (mg/L)	140	E200.8	0.01
Iron-Dissolved (mg/L)	140	E200.7	0.03
Lead-Dissolved (mg/L)	140	E200.8	0.001
Manganese-Dissolved (mg/L)	140	E200.8	0.01
Mercury-Dissolved (mg/L)	140	E200.8	0.001
Molybdenum-Dissolved (mg/L)	140	E200.8	0.1
Nickel-Dissolved (mg/L)	140	E200.8	0.05

Table 2.7-30: Number of Groundwater Samples Collected, Analytical Method, and PQL by Constituent (cont'd)

Constituent, Unit	Number of samples analyzed	Analytical Method	PQL[1]
Selenium-Dissolved (mg/L)	140	A3114 B	0.001
Selenium-IV-Dissolved (mg/L)	118	A3114 B	0.001
Selenium-VI-Dissolved (mg/L)	118	A3114 B	0.001
Silver-Dissolved (mg/L)	140	E200.8	0.005
Thorium 232-Dissolved (mg/L)	140	E200.8	0.005
Uranium-Dissolved (mg/L)	140	E200.8	0.003
Vanadium-Dissolved (mg/L)	140	E200.8	0.1
Zinc-Dissolved (mg/L)	140	E200.8	0.01
Metals, Suspended			
Uranium-Suspended (mg/L)	138	E200.8	0.0003
Metals, Total			
Antimony-Total (mg/L)	95	E200.8	0.003
Arsenic-Total (mg/L)	95	E200.8	0.001
Barium-Total (mg/L)	95	E200.8	0.1
Beryllium-Total (mg/L)	95	E200.8	0.001
Boron-Total (mg/L)	95	E200.7	0.2
Cadmium-Total (mg/L)	95	E200.8	0.005
Chromium-Total (mg/L)	95	E200.8	0.05
Copper-Total (mg/L)	95	E200.8	0.01
Iron-Total (mg/L)	95	E200.7	0.03
Lead-Total (mg/L)	95	E200.8	0.001
Manganese-Total (mg/L)	95	E200.8	0.01
Mercury-Total (mg/L)	163	E200.8	0.001
Molybdenum-Total (mg/L)	95	E200.8	0.1
Nickel-Total (mg/L)	95	E200.8	0.05
Selenium-Total (mg/L)	95	E200.8	0.002
Silver-Total (mg/L)	95	E200.8	0.005
Strontium-Total (mg/L)	95	E200.8	0.1
Thallium-Total (mg/L)	95	E200.8	0.001
Uranium-Total (mg/L)	99	E200.8	0.0003
Zinc-Total (mg/L)	95	E200.8	0.01
Radionuclides			
Gross Alpha-Dissolved (pCi/L)	140	E900.0	1
Gross Beta-Dissolved (pCi/L)	140	E900.0	2
Gross Gamma-Dissolved (pCi/L)	140	E901.1	20
Lead 210-Dissolved (pCi/L)	140	E909.0M	1
Lead 210-Suspended (pCi/L)	138	E909.0M	1
Lead 210-Total (pCi/L)	20	E909.0M	1
Polonium 210-Dissolved (pCi/L)	140	RMO-3008	1
Polonium 210-Suspended (pCi/L)	138	RMO-3008	1

Table 2.7-30: Number of Groundwater Samples Collected, Analytical Method, and PQL by Constituent (conclusion)

Constituent, Unit	Number of samples analyzed	Analytical Method	PQL[1]
Polonium 210-Total (pCi/L)	20	RMO-3008	1
Radium 226-Dissolved (pCi/L)	134	E903.0	0.2
Radium 226-Suspended (pCi/L)	133	E903.0	0.2
Radium 226-Total (pCi/L)	90	E903.0	0.2
Radon 222-Total (pCi/L)	120	D5072-92	100
Thorium 230-Dissolved (pCi/L)	140	E907.0	0.2
Thorium 230-Suspended (pCi/L)	138	E907.0	0.2
Thorium 230-Total (pCi/L)	20	E907.0	0.2

[1]PQL = Practical Quantitation Limit. The concentration that can be reliably measured within specified limits during routine laboratory operating conditions, below which results are reported as "less than reporting limit". The contracting laboratory uses the PQL as the reporting limit.

2.7.3.2.2 Groundwater Quality Sampling Results

This section presents a summary of analyses of recent groundwater quality samples. Field measurements, laboratory results, and comparisons are presented in the following sections. Complete groundwater quality data results are available in Appendix 2.7-G.

2.7.3.2.2.1 Results for Field Parameters

Results of the groundwater field data gathered during well sampling activities are presented below. Table 2.7-30 gives summary statistics for temperature, dissolved oxygen, specific conductivity, pH, and turbidity for all field data. Tables 2.7-31 and 2.7-32 give field parameter statistics for Lakota, Fall River, and Inyan Kara wells where samples were collected monthly and quarterly, respectively. Table 2.7-33 gives field parameter statistics for alluvial well samples. A comparison of pH and specific conductance values for field and laboratory measurements reveals that laboratory results are within reasonable limits. Most pH values taken in the field are within a few hundredths to few tenths of a pH unit from that measured in the laboratory. For example, the highest pH recorded was 12.67 during sampling of Fall River well 691 on July 1, 2008. The high pH value was verified by the contracting laboratory which reported a pH of 12.4 in the sample. (This represents extremely alkaline water far outside the typical range of groundwater pH. Based on drill core, beds of the Fall River Formation in this area can be extremely well cemented with calcite.)

In the field, a maximum specific conductance of 12,220 uS/cm was measured at alluvial well 677 on September 28, 2007. The laboratory measured a specific conductance of this sample of 11,000 uS/cm. It is important to note that the laboratory conductance is given for the sample at 25°C and at the time of field measurements, the temperature of nearly every sample was much lower.

Table 2.7-31: Statistics for all Field Parameters Collected During Well Sampling Activities

	Temperature, C	pH	Dissolved Oxygen, mg/L	Specific Conductance, uS/cm	Turbidity, NTU
N	156	165	99	169	136
Mean	12.62	7.63	1.29	2122	25.7
StDev	2.09	0.77	2.17	1843	133
Q1	11.73	7.10	0.17	1250	0.6
Median	12.63	7.62	0.29	1409	3.2
Q3	14.08	7.92	1.35	2390	7.5
Min	0.75	6.09	0.02	740	-0.4
Max	16.08	12.67	10.02	12220	1092

N = The number of measurements for a particular parameter.
Mean = Arithmetic mean
StDev = Standard deviation
Q1 = First Quartile. The value holding ranked position 0.25 x (n + 1) for each parameter. Value may be interpolated.
Median = The middle value of ranked n. Value may be interpolated.
Q3 = Third Quartile. The value holding ranked position 0.75 x (n + 1) for each parameter. Value may be interpolated.
Min = The minimum value recorded from all wells
Max = The maximum value recorded from all wells

Table 2.7-32: Field Parameter Statistics for Inyan Kara Wells (Monthly)

	Temperature, C	pH	Dissolved Oxygen, mg/L	Specific Conductance, uS/cm	Turbidity, NTU
N	82	79	53	82	78
Mean	13.41	7.54	0.33	1593	7.2
StDev	1.39	0.76	0.58	611	10.5
Q1	12.33	7.03	0.12	1176	0.7
Median	13.15	7.53	0.19	1345	4.35
Q3	14.56	7.8	0.27	2196	7.5
Min	10.86	6.09	0.02	925	-0.2
Max	16.08	10.79	3.83	3098	71

Table 2.7-33: Field Parameter Statistics for Inyan Kara Wells (Quarterly)

	Temperature, C	pH	Dissolved Oxygen, mg/L	Specific Conductance, uS/cm	Turbidity, NTU
n	42	51	29	53	36
Mean	11.63	7.79	1.80	1469	4.2
StDev	2.59	0.40	1.82	419	9.4
Q1	11.21	7.5	0.43	1214	0.3
Median	11.96	7.86	1.32	1408	0.70
Q3	12.74	8.07	1.87	1579	2.2
Min	0.75	6.96	0.05	740	-0.4
Max	15.78	8.65	7.09	2390	40.9

Table 2.7-34: Field Parameter Statistics for Alluvial Wells

	Temperature, C	pH	Dissolved Oxygen, mg/L	Specific Conductance, uS/cm	Turbidity, NTU
n	18	20	11	19	10
Mean	10.91	7.06	4.53	5964	268
StDev	2.03	0.26	4.05	3195	438
Q1	9.15	6.93	0.91	2920	3
Median	10.99	7.04	1.67	5872	16.9
Q3	12.17	7.18	8.83	6779	505
Min	7.67	6.32	0.55	2609	1.4
Max	15.18	7.52	10.02	12220	1092

2.7.3.2.2.2 Results for Laboratory Parameters

Summary statistics for baseline monitoring program laboratory samples are contained in Appendices 2.7-H and 2.7-I. Appendix 2.7-H gives statistics for all groundwater constituents detected at or above PQL by constituent. Appendix 2.7-I gives the minimum and maximum value for all sampled constituents detected at or above the PQL, and the site ID and date of the sample that had minimum and maximum detection value. Complete laboratory analytical results for each well are provided in Appendix 2.7-G.

2.7.3.2.3 Comparison of Site Baseline Water Quality to Drinking Water Standards

2.7.3.2.3.1 EPA and South Dakota Primary Drinking Water Standards

Table 2.7-34 gives current National Primary and Secondary Drinking Water Standards as regulated by EPA. Also listed is the number of samples analyzed for each constituent, the total number of detections above the reporting limit, and the total number of detections equal to or above the Maximum Contaminant Level (MCL) for each constituent. These standards or Maximum Contaminant Levels (MCL) are enforced by the EPA on public drinking water systems but can only serve as a guide for private water systems. Private water systems, as defined by the EPA, serve less than 25 people and have less than 15 service connections; all other systems are defined as public water systems. All drinking water wells within the PAA are private water systems.

As of August 24, 2004 all of the South Dakota Drinking Water Standards rules (ARSD 74:04:05) and Public Notice rules (ARSD 74:04:06) were repealed. In their place is ARSD 74:04:12. This new rule adopts by reference the latest published version of the Code of Federal Regulations (40 CFR Part 141), making South Dakota drinking water standards the same as EPA Primary Drinking Water Quality standards (Table 2.7-34).

Table 2.7-35: Sampling Statistics with 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
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	0.030	102	77	18
Zinc, Zn	mg/L	5 [1]; 2 [2]	98	35	0

Table 2.7-35: Sampling Statistics with Water Quality Regulatory Limits for Public Drinking Water Supply Systems (conclusion)

Test Analyte/Parameter	Units	EPA Maximum Contaminant Level (MCL)	Number of Samples Analyzed*	Number of Detections	Number of Detections equal to or above MCL
RADIONUCLIDES					
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
N/A – Not available
* 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.

2.7.3.2.3.2 Exceedances of Primary Drinking Water Standards

A number of groundwater samples collected at the project site exceeded the National Primary Drinking Water Standards. Constituents with samples exceeding the standards include arsenic (Table 2.7-36), lead (Table 2.7-37), uranium (Table 2.7-38), radium-226 (Table 2.7-39 to 2.7-41), and gross alpha particles (Table 2.7-42); these tables provide constituent concentrations, well ID, and sample date for regulated constituents detected at or above MCL levels.

As shown on the table, nearly 75 percent of the samples exceeded the MCL for gross alpha particles (15 pCi/L), with the exceedances occurring in samples from the Inyan Kara aquifer and alluvial aquifer. 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 6500 pCi/L. Two of the three wells (680 and 681) having gross alpha concentrations over 1000 pCi/L are known to be directly within an orebody. The third is downgradient of open pit mines within the Fall River Formation.

Each sample collected from wells 615 and 3026 exceeded the MCL for arsenic. Also, half of all uranium exceedances are from alluvial aquifer samples.

2.7.3.2.3.3 Exceedances of Other Drinking Water Standards

In addition to primary drinking water standards established by the EPA, EPA Region 8 has set primary standards for some constituents. There are also a number of constituents (including radon-222) that have proposed standards which have not yet been adopted. Secondary drinking water standards (SMCL) 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. These constituents, along with the number of samples that exceed these guidelines, are presented in 2.7-34.

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. All of the samples exceeded the recommended concentration of TDS. Values of TDS ranged from 670 to 9700 mg/L with the highest values obtained from alluvial well samples.

A number of samples also exceeded the SMCL for sodium and sulfate. A total of 63 samples exceeded the secondary standard for sodium with values ranging from 201 to 2140 mg/L. The highest values of sodium were again from alluvial well samples. 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 1000 mg/L sulfate. Fourteen samples had concentrations of sulfate over 3000 mg/L, all of which were from the alluvial aquifers.

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 of 5.0 mg/L. The only water supply wells exceeding the Region 8 limit for iron are stock wells 619 and 650. The SMCL for manganese was exceeded by 89 of 98 samples; the Region 8 limit of 0.8 mg/L was exceeded by 19 samples. Values of manganese over the secondary guideline range from 0.05 to 3.4 mg/L. Strontium was 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 SMCL exceeded trace metals including boron, iron, manganese, and strontium.

Currently, there is no primary drinking water standard for Radon-222. The proposed EPA MCL is 300 pCi/L. Of the 121 samples analyzed for Radon-222 as part of the project baseline sampling program, 105 samples exceed the recommended level. Values of samples exceeding the limit range from 304 to 462000 pCi/L. Thirty-six samples have over 10 times the recommended concentration of radon-222; 20 of these samples are over 100 times the proposed MCL. The wells with the highest concentration include wells 680 and 681, which are directly in a known orebody, and well 42, a private well used for domestic and stock water. The only well not exceeding the radon-222 limit is well 650, a Lakota well upgradient of historic uranium production activities.

Table 2.7-36: Samples with Arsenic (Total) Results Equal to or Greater than the Arsenic MCL of 0.01 mg/L

Well	Sample Date	Result, mg/L	Well Use
615	01-Apr-08	0.024	Monitoring
615	01-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	05-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

Table 2.7-37: Samples with Lead (Total) Results Equal to or Greater than the Lead MCL of 0.015 mg/L

Well	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	05-Feb-08	0.06	Alluvial Monitoring
679	03-Feb-08	0.015	Alluvial Monitoring
679	18-May-08	0.022	Alluvial Monitoring
689	25-Jun-08	0.017	Monitoring

Table 2.7-38: Samples with Uranium (total) Results Equal to or Greater than the Uranium MCL of 0.03 mg/L

Well	Sample Date	Result, mg/L	Well Use
675	05-Feb-08	0.0387	Alluvial Monitoring
675	29-Apr-08	0.0502	Alluvial Monitoring
675	29-Apr-08	0.0516	Alluvial Monitoring
676	05-Feb-08	0.0687	Alluvial Monitoring
676	29-Apr-08	0.0591	Alluvial Monitoring
677	05-Feb-08	0.0414	Alluvial Monitoring
677	29-Apr-08	0.0471	Alluvial Monitoring
678	05-Feb-08	0.0379	Alluvial Monitoring
678	05-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

Table 2.7-39: Samples with Radium-226 (Dissolved) Results Equal to or Greater than the Radium-226 MCL of 5 pCi/L

Well	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
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

Table 2.7-39: Samples with Radium -226 (Dissolved) Results Equal to or Greater than the Radium-226 MCL of 5 pCi/L (conclusion)

Well	Sample Date	Result, pCi/L	Well Use
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

Note: Radium-228 was not analyzed due to the absence of Thorium-232 in samples

Table 2.7-40: Samples with Radium-226 (Suspended) Results Equal to or Greater than the Radium-226 MCL of 5 pCi/L

Well	Sample Date	Result, pCi/L	Well Use
42	05-Feb-08	5.1	Domestic
619	24-Mar-08	11.4	Stock
619	17-Jun-08	8.8	Stock
676	05-Feb-08	11.4	Alluvial Monitoring
679	03-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

Note: Radium-228 was not analyzed due to the absence of Thorium-232 in samples

Table 2.7-41 Samples with Radium-226 (Total) Results Equal to or Greater than the Radium-226 MCL of 5 pCi/L

Well	Sample Date	Result, pCi/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

Note: Radium-228 was not analyzed due to the absence of Thorium-232 in samples

Table 2.7-42: Samples with Gross Alpha (Total) Results Equal to or Greater than the Gross Alpha MCL of 15 pCi/L

Well	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
622	1-Apr-08	15	Monitoring
622	21-Apr-08	22.6	Monitoring
622	28-May-08	32.6	Monitoring

Table 2.7-42: Samples with Gross Alpha (Total) Results Equal to or Greater than the Gross Alpha MCL of 15 pCi/L (cont'd)

Well	Sample Date	Result, pCi/L	Well Use
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
681	30-Mar-08	2170	Monitoring
681	21-Apr-08	1400	Monitoring
681	12-May-08	2220	Monitoring
681	18-May-08	1220	Monitoring

Table 2.7-42: Samples with Gross Alpha (Total) Results Equal to or Greater than the Gross Alpha MCL of 15 pCi/L (concl.)

Well	Sample Date	Result, pCi/L	Well Use
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

2.7.3.2.4 Comparison of Historical and Recent Water Quality near the Project

An analysis was conducted to determine if the well chemistry data collected at the PAA by the Tennessee Valley Authority (TVA) between May 1979 and April 1984 is representative of current water quality conditions and could therefore be used to expand the current Powertech (USA) data set. Nine wells were selected for analysis based on TVA and Powertech (USA) data sets being available for each well, time period, and constituent (Figure 2.7-22). All nine wells are completed into the Inyan Kara Group, which is composed of the Lakota and Fall River formations. Five of the wells are completed into the Lakota formation, three in the Fall River formation, and one is classified as simply the Inyan Kara formation.

Powertech (USA) and TVA data comparison consisted of two phases: (1) computing basic statistics on selected data, and (2) plotting Piper diagrams. The same set of wells was used in both analyses. Table 2.7-42 lists wells, the aquifer they are completed into, and the number of sample results available for analysis from monitoring programs done by TVA and Powertech (USA). Table 2.7-43 shows the constituents sampled for during TVA data collection and those used in the comparison analysis either with statistics or Piper diagrams. Because the Powertech (USA) program is ongoing, the sample number is the number of samples analyzed through August 2008. Data selection process, analysis details, and results from statistical analyses and Piper plots are summarized independently in the following sections.

The following procedures were followed in completing the analyses:

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

The number of samples analyzed during the current monitoring program limited the sample size available for statistical analysis. Therefore the analyses techniques available were limited to less rigorous qualitative and quantitative techniques. Comparison statistics reported are mean, minimum, and maximum, with relative percent difference (RPD) calculated for each statistic, where RPD is the absolute difference divided by the average (Table 2.7-44). Complete groundwater quality data results are available in Appendix 2.7-G (Powertech (USA) results) and Appendix 2.7-J (TVA results).

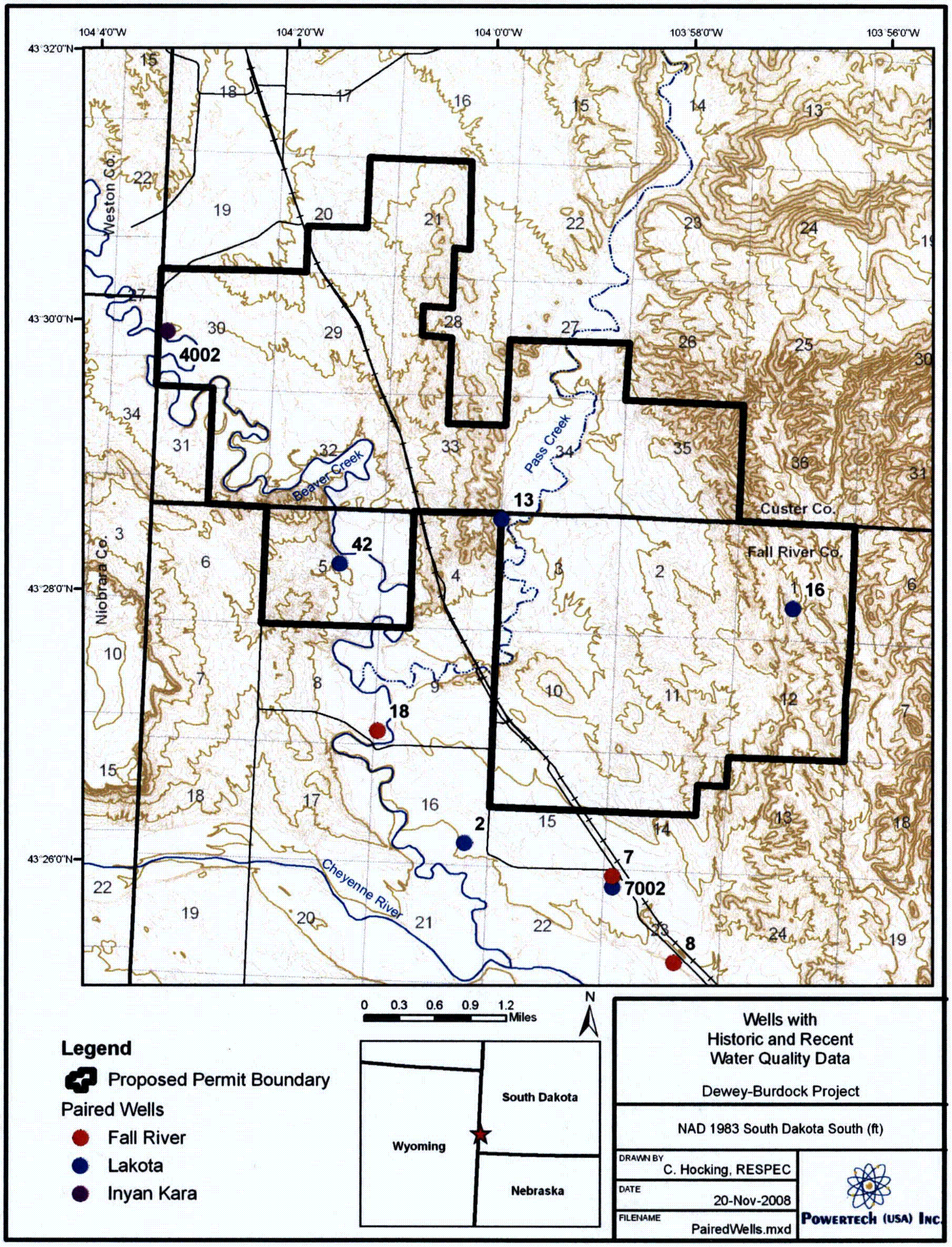


Figure 2.7-22: Wells with Historic and Recent Water Quality Data

Table 2.7-43: Water Quality Sampling from Previous Uranium Exploration Era as well as from Recent Exploration

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

Table 2.7-44: Parameters Analyzed During TVA Water Quality Monitoring

Test Analyte/Parameter	Units	Notes	Used in Historic/Recent Comparison
BULK PROPERTIES			
pH	pH Units	Field and Laboratory Program	X
Total Dissolved Solids (TDS)	mg/L		X
Total Suspended Solids (TSS)	mg/L		
Water Level	ft		
Conductivity	µmhos/cm	Field and Laboratory Program	X
Hardness			
CATIONS/ANIONS			
Calcium	mg/L		X
Alkalinity	mg/L		X
Bicarbonate (as HCO_3)	mg/L		X
Carbonate (as $CaCO_3$)	mg/L		X
Magnesium	mg/L		X
Potassium	mg/L		X
Sodium	mg/L		X
Sulfate	mg/L		X
Chloride	mg/L		X
Phosphate	mg/L		
Nitrogen	mg/L		
Cation/Anion Balance	%		

Table 2.7-15: Parameters Analyzed During TVA Water Quality Monitoring (cont'd)

Test Analyte/Parameter	Units	Notes	Used in Historic/Recent Comparison
TRACE METALS			
Boron, B	mg/L	Dissolved	
Iron, Fe	mg/L	Dissolved	
Manganese, Mn	mg/L	Dissolved	
Lead, Pb	mg/L	Dissolved	
Selenium, Se	mg/L	Dissolved: Speciated	
Silcon-SiO_2	mg/L		
Uranium, U	mg/L	Total	
Vanadium, V	mg/L		
Zinc, Zn	mg/L	Dissolved	
RADIONUCLIDES			
Radium-226	pCi/L	Total	

Average alkalinity decreased slightly for all wells sampled except for No. 16 and No. 7002 which had essentially the same mean alkalinity in both time periods. The average absolute difference of the mean value of alkalinity was approximately 7 percent in the two data sets. The minimum value statistic at No. 2 showed the greatest RPD (78 percent) between TVA and Powertech (USA) data; one sample had an alkalinity of 88 mg/L while the other three ranged from 208 mg/L to 214 mg/L. A plot comparing average alkalinity between TVA and Powertech (USA) data is given in Figure 2.7-23; this plot both includes and excludes the low value at No. 2 well in the mean calculation.

Conductivity was overall slightly greater (8 percent) than in previous sampling years. It decreased slightly in No.16 and was essentially the same in No. 13 and No. 7002. The greatest increase in conductivity was found in No.2 (from 1547 to 2285 umhos/cm); although with the exclusion of an outlier (4400 umhos/cm) the mean of Powertech (USA) samples is 1580 umhos/cm. Figure 2.7-24 is a plot of average conductivity compared between historic TVA and current Powertech (USA) data both including and excluding the outlier value at No. 2 well in the mean calculation.

Values of pH were slightly higher in Powertech (USA) samples than in TVA samples, with the exception of wells No.2 and No. 7002 (Figure 2.7-25). Mean pH values varied from 7.44 to 8.11 at wells with greater than five samples. The greatest difference in pH was at well No. 7, with mean pH of 8.5 for TVA data and mean pH of 8.11 for Powertech (USA) data.

The TDS values from the two different sampling periods were also very similar. The greatest difference was once again at well No.2 that had a mean of 1043 mg/L in the TVA era compared to 1750 mg/L in the current sampling period. One Powertech (USA) sample collected at No. 2 well had a TDS value of 3700 mg/L, while the other Powertech (USA) samples were the same at 1100 mg/L. Figure 2.7-26 gives a comparison between historic TVA and current Powertech (USA) mean TDS, showing the mean calculated both including and excluding the outlier value at well No. 2.

Table 2.7-45: Comparison of Statistics for Selected Constituents between Historic TVA Data and Current Powertech Data

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

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

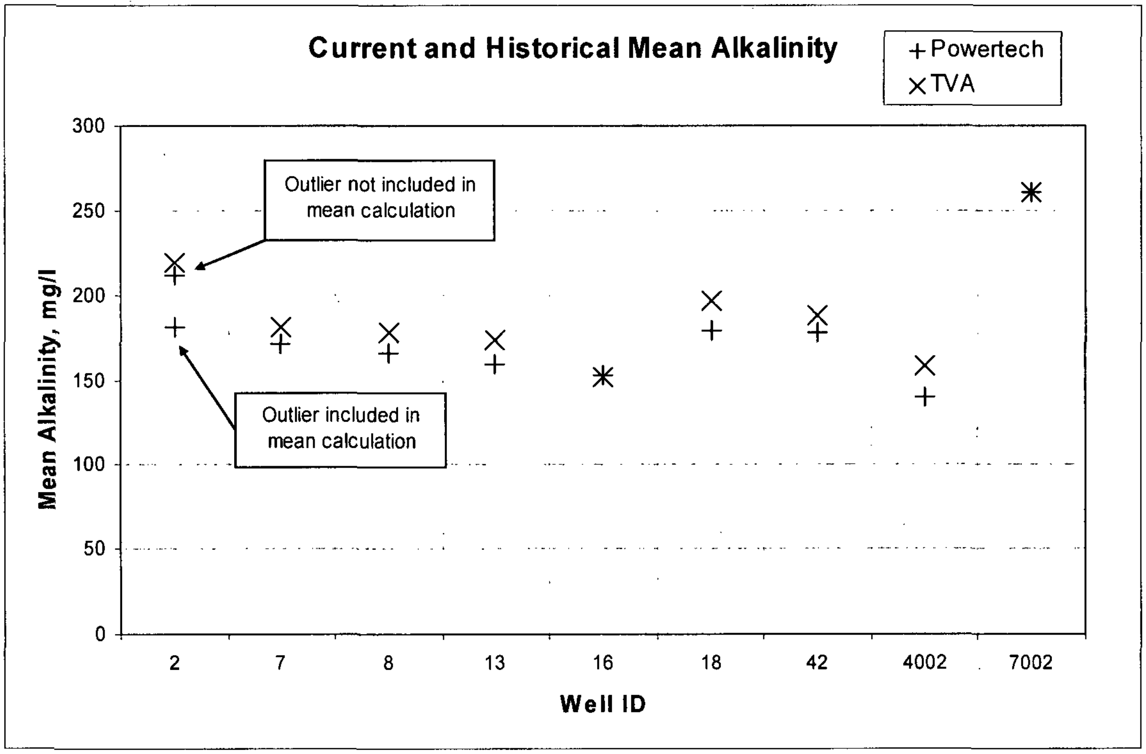


Figure 2.7-23: Mean Alkalinity Comparison between Historic TVA and Current Powertech Data

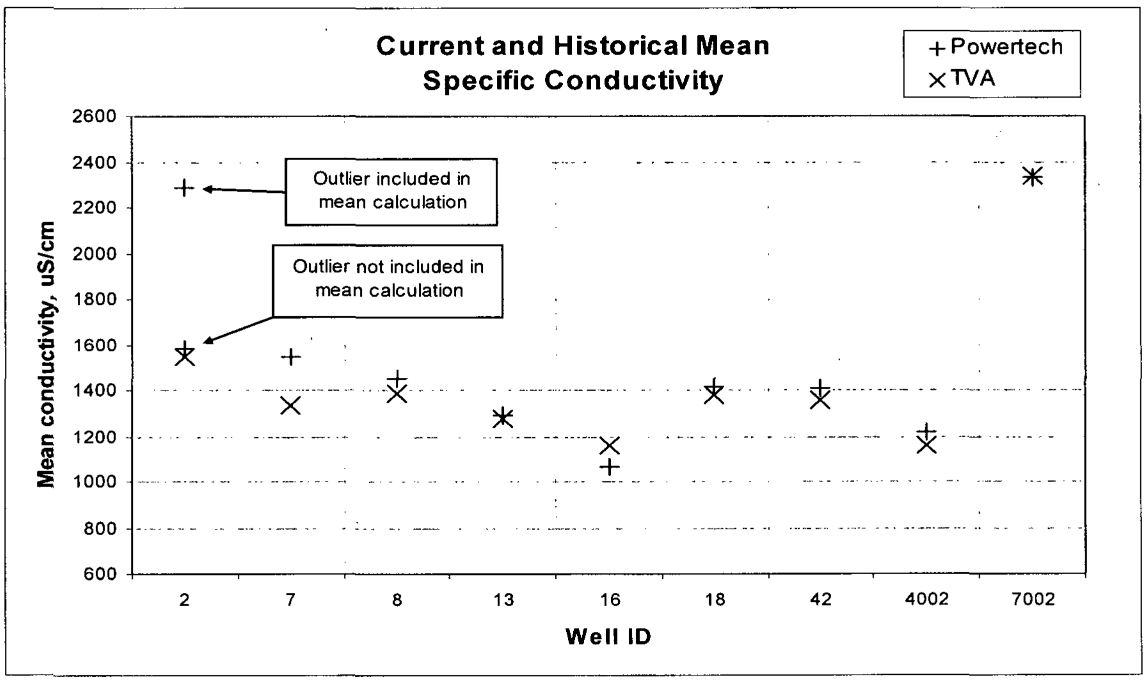


Figure 2.7-24: Mean Conductivity Comparison between Historic TVA and Current Powertech Data

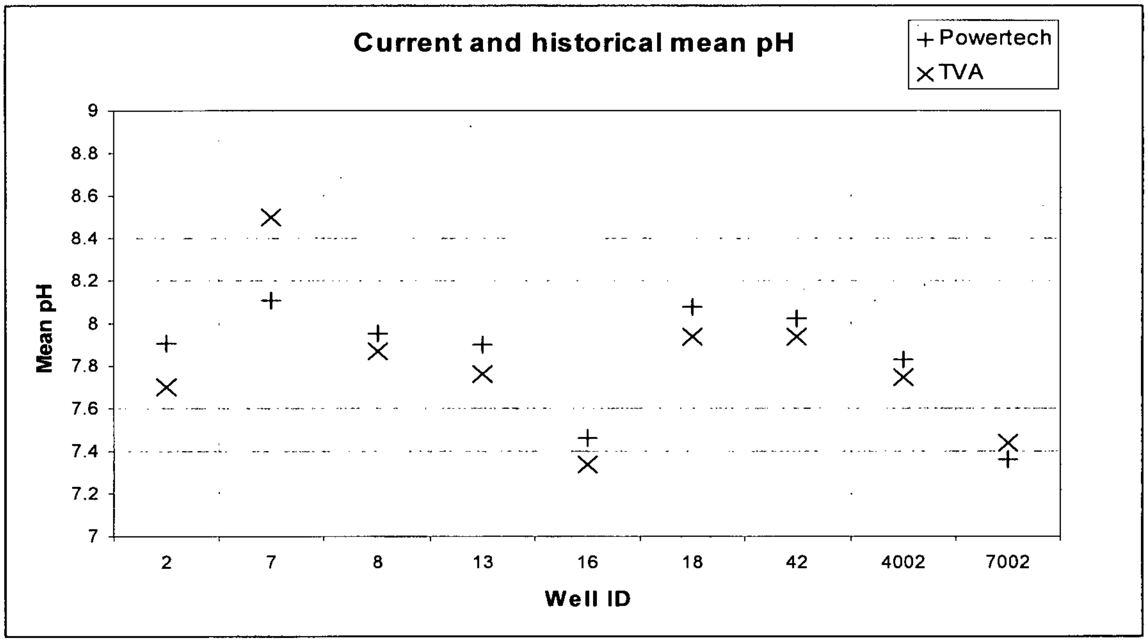


Figure 2.7-25: Mean pH Comparison between Historic TVA and Current Powertech Data

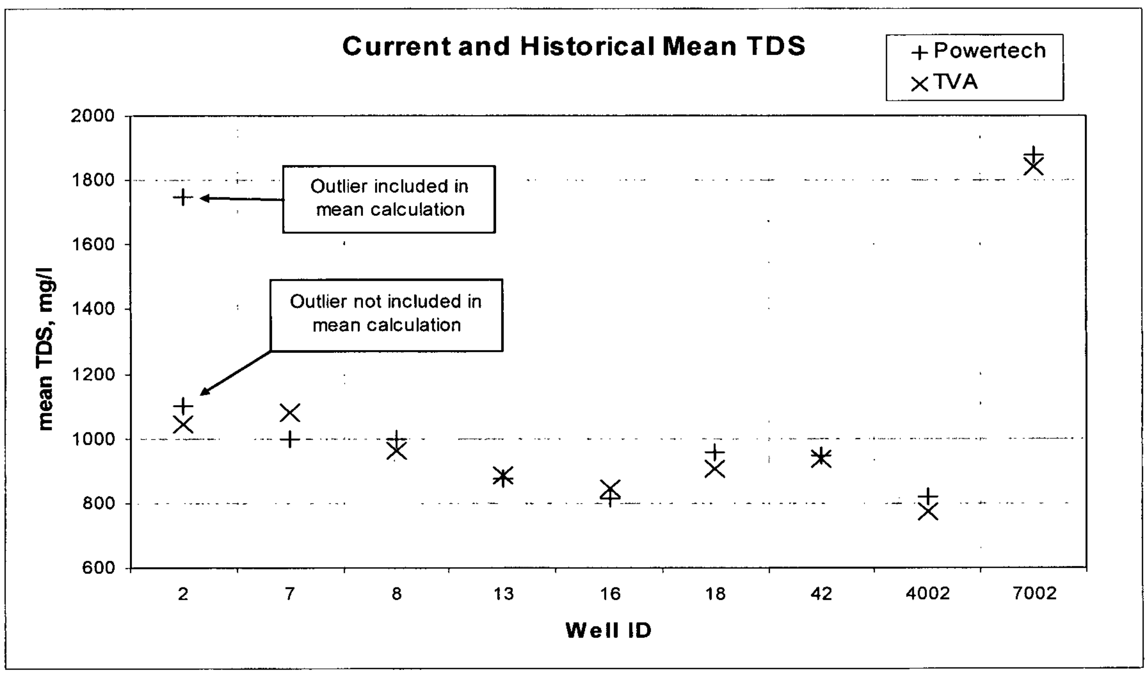


Figure 2.7-26: Mean TDS Comparison between Historic TVA and Current Powertech Data

Piper diagrams were constructed for this group of wells with both historic and recent samples to determine if the general water quality type has changed over the course of the last 30 years (Figures 2.7-27 through 2.7-31). Piper diagrams are a useful tool to evaluate overall water quality as they provide a visual representation of the proportional concentrations of major ions. These figures consist of two trilinear diagrams (one for each cations and anions) and a comprehensive quadrilateral diagram. The trilinear diagrams illustrate the relative concentrations of cations (left diagram) and anions (right diagram) in each sample plotted as percent of total in milliequivalents per liter (meq/l). Cations included on the diagram include sodium (Na+) plus potassium (K+), calcium (Ca++), and magnesium (Mg++). Anions plotted include bicarbonate (HCO3-) plus carbonate (CO3--), sulfate (SO4--), and chloride (Cl-). Each sample is represented by a point in each trilinear diagram. The quadrilateral field at the top of the Piper diagram is designed to show both anion and cation groups and is used to assign a general water type.

Inspection of the resulting Piper diagrams reveals that water quality within both the Fall River and Lakota formations display a similar distribution. For both formations, sulfate is by far the dominant anion accounting for 70 to 80 percent meq/l (Figure 2.7-27). Relative abundance of calcium and magnesium are fairly even though most samples have a slightly higher percentage of calcium. Most samples contain between 55 and 85 percent meq/l sodium although water from the Lakota has a greater fluctuation with a group of samples having only 20 to 30 percent meq/l of sodium. Figures 2.7-28 and 2.7-29 display the water major ion concentrations sorted by aquifer and historical and recent data sets. In general, both the historic and recent data sets display the same trends and range in water type grading between a calcium-magnesium sulfate to sodium sulfate type.

Figures 2.7-30 and 2.7-31 display the proportional concentrations of major ions symbolized by well. These diagrams illustrate that samples for a particular well form a cluster, and hence it can be said that water quality has not greatly varied by sampling event. It is also apparent that the water type is variable from well to well. The geographical location and distance from the outcrop are therefore believed to be the main influences on water type, although well depth and screened interval may also have an effect. Wells that are located on or near the Inyan Kara outcrop (well 16 for example) yield a more calcium-magnesium sulfate type water, whereas wells further downgradient evolve to a sodium sulfate type water. This finding is consistent with that of Gott et al. (1974), who believed the difference in water type distribution resulted from recharge to the Inyan Kara from upward leaking Minnelusa aquifer water. It can be concluded that relative ion concentration of Inyan Kara formation water is similar today to what it was during TVA sampling in the PAA.

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

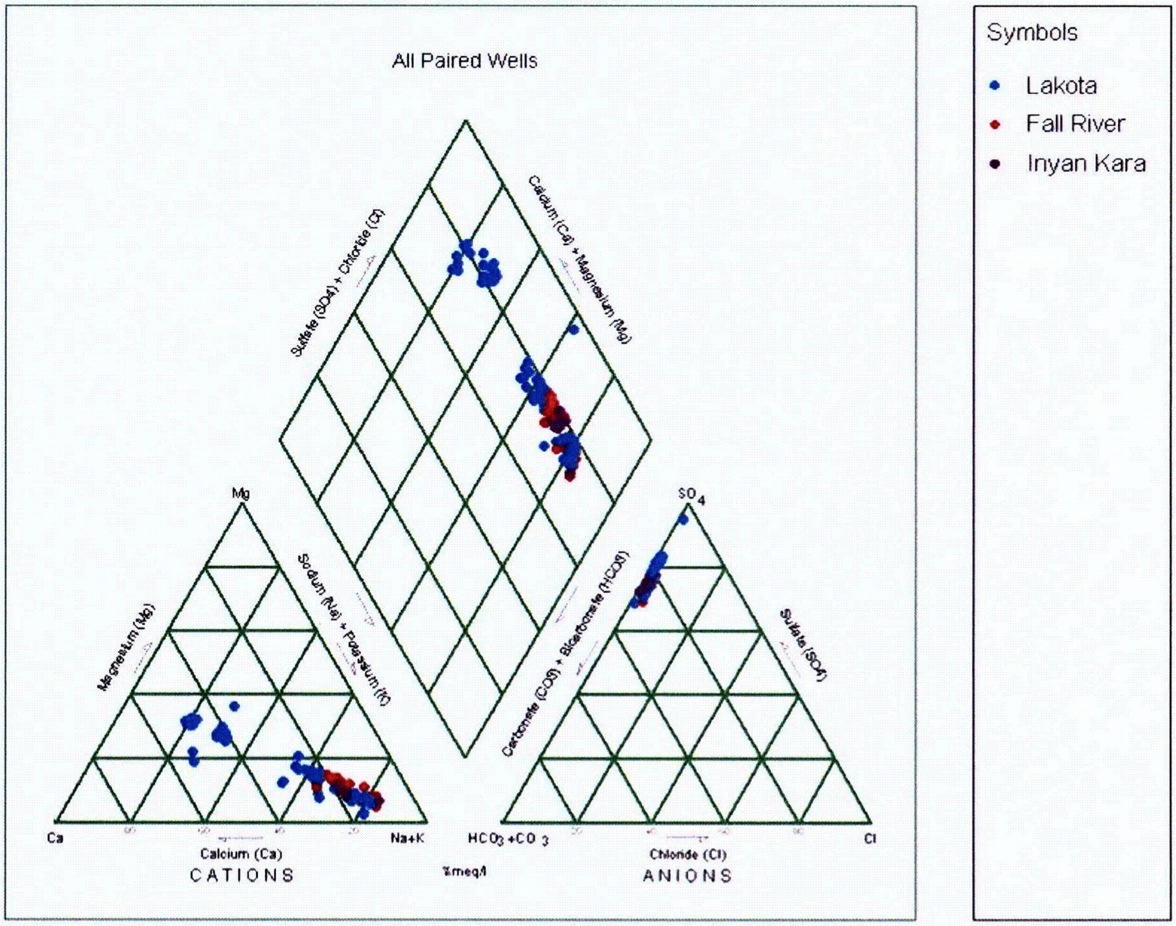


Figure 2.7-27: Piper Diagram of Well Data Grouped by Formation for Wells Sampled by TVA and Powertech

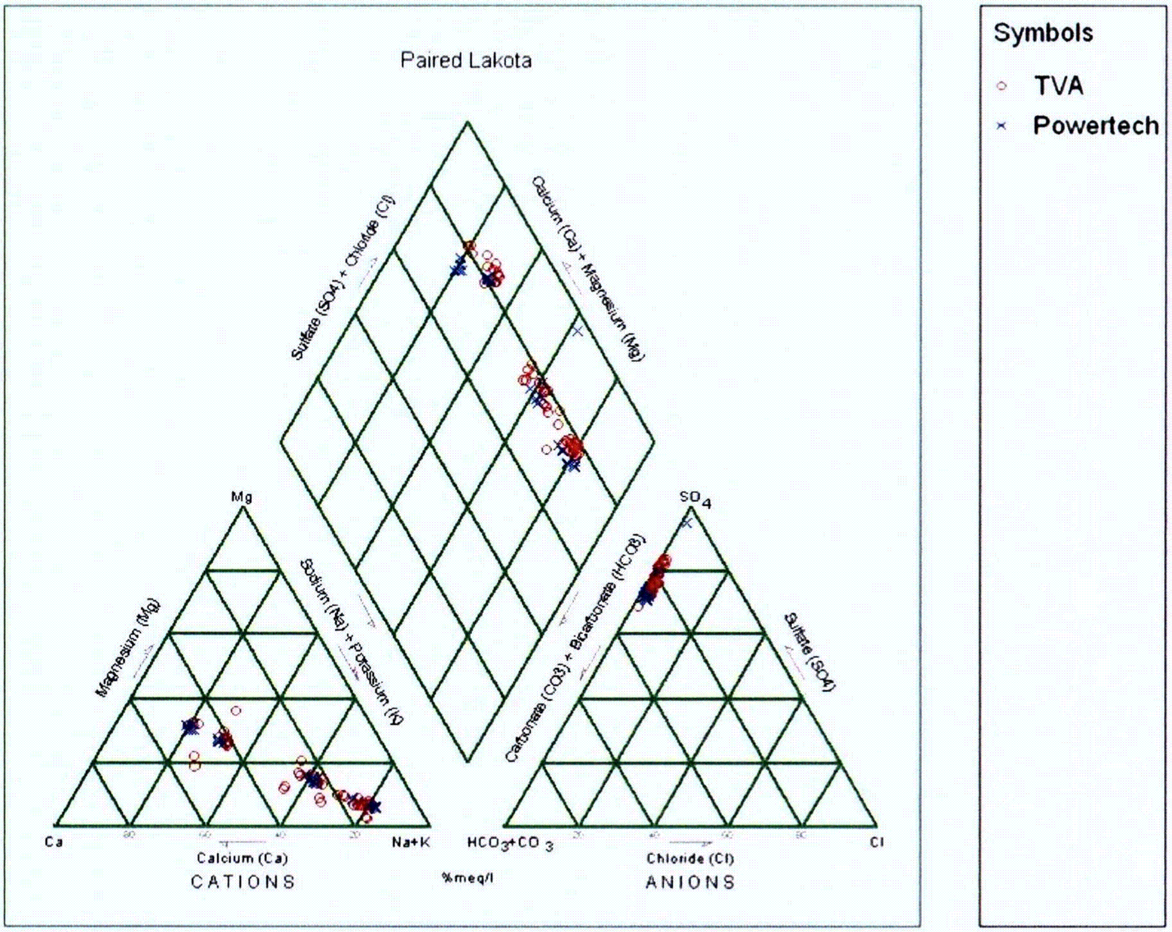


Figure 2.7-28: Piper Diagram of Sample Results from Lakota Wells Grouped by Vintage

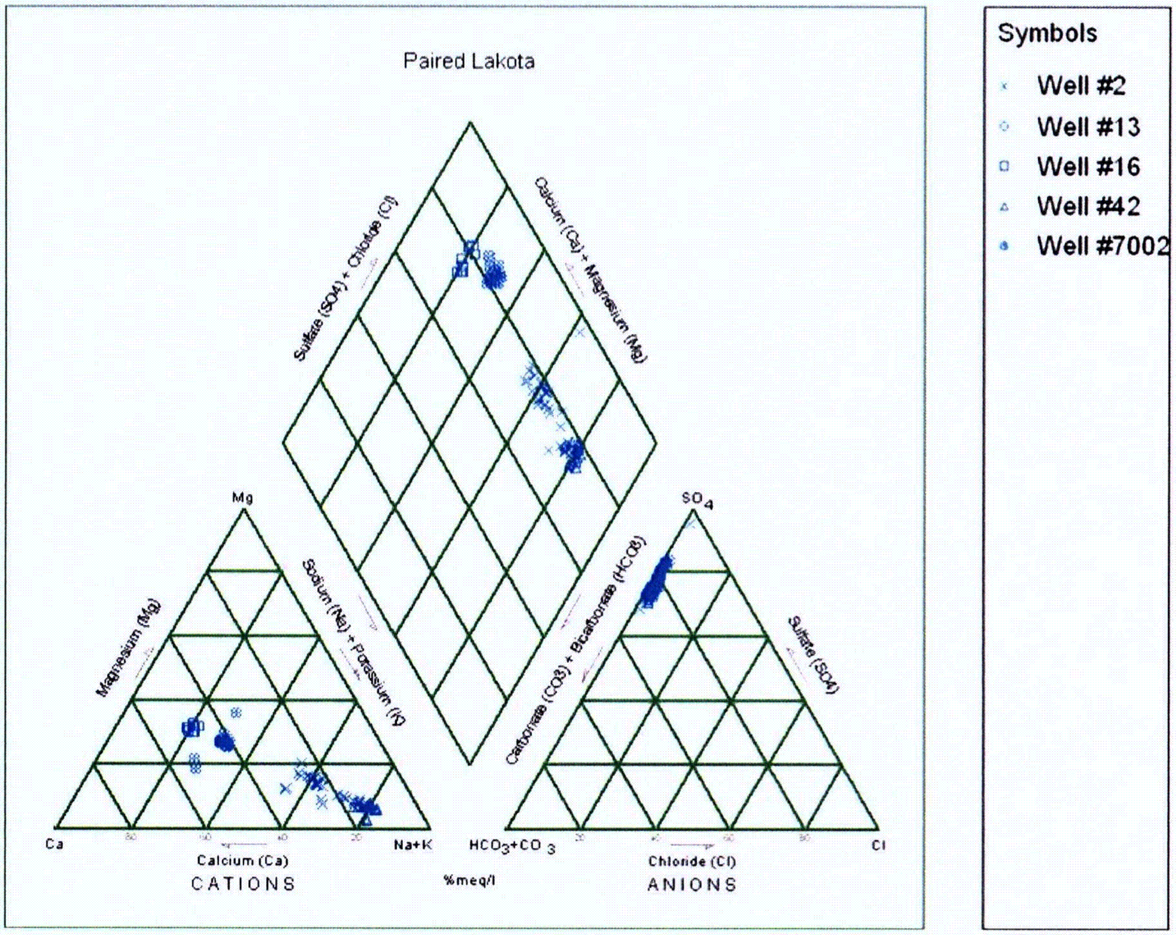


Figure 2.7-29: Piper Diagram of Sample Results from Wells Sampled in the Lakota Formation by TVA and Powertech Grouped by Well

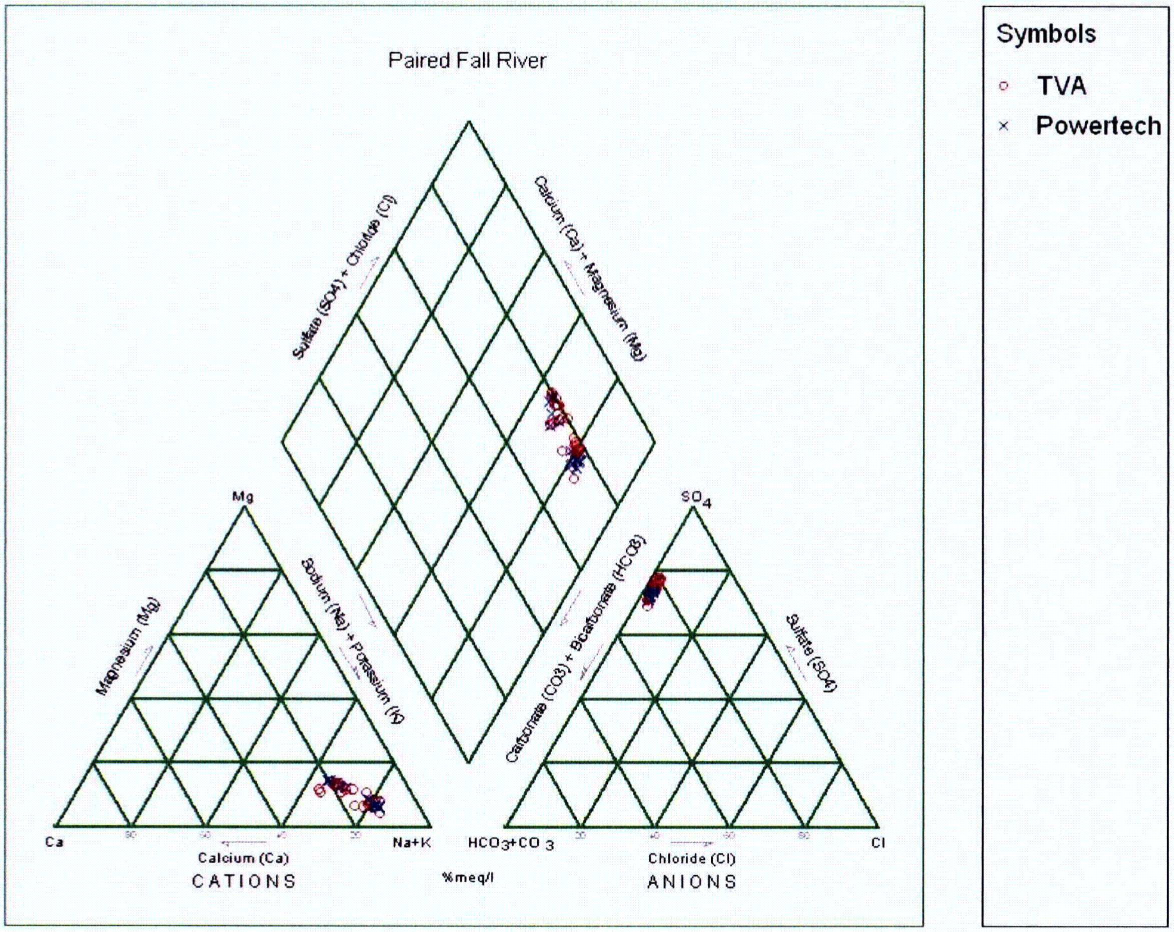


Figure 2.7-30: Piper Diagram of Sample Results from Fall River Wells Grouped by Vintage

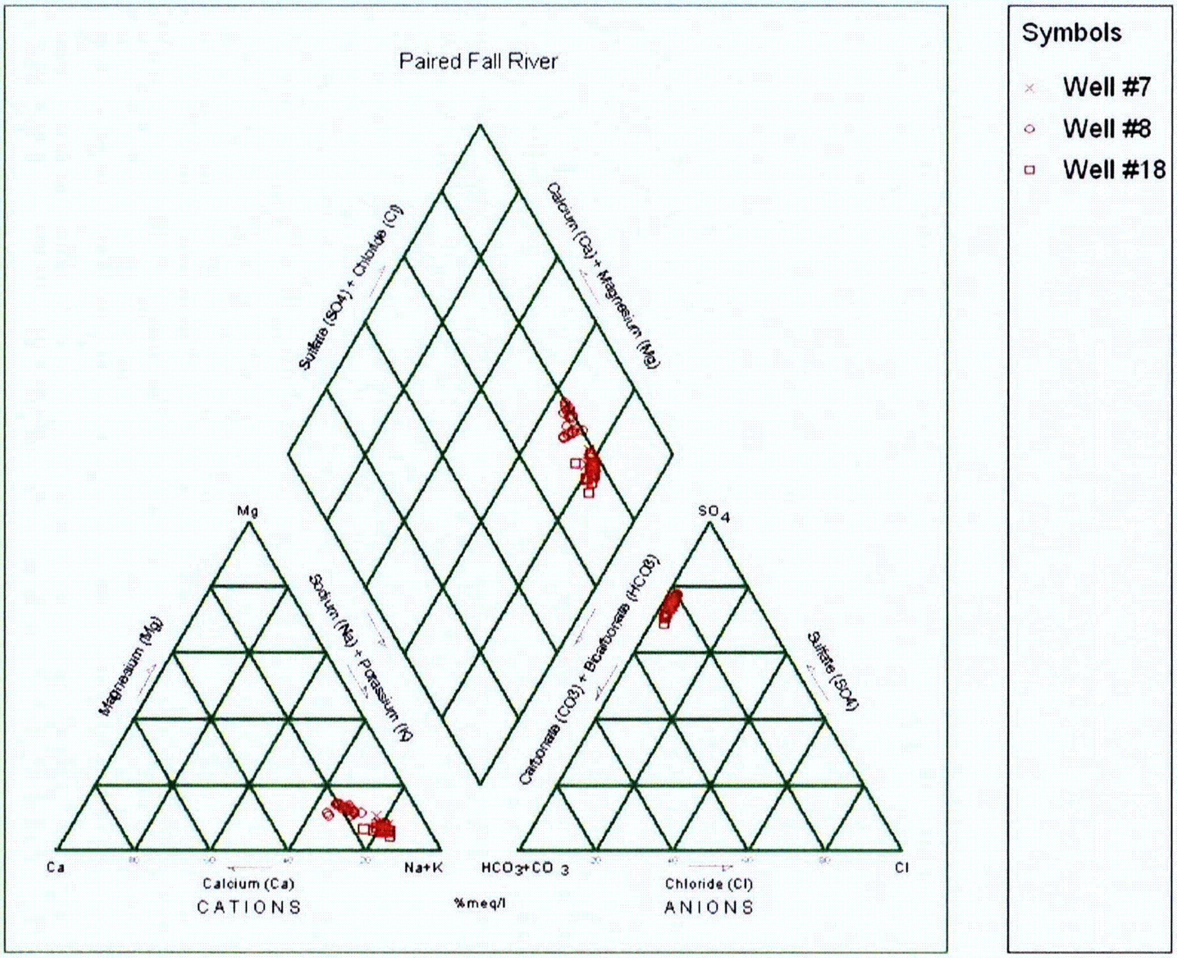


Figure 2.7-31: Piper Diagram of Sample Results from Wells Sampled in the Fall River Formation by TVA and Powertech Grouped by Well

2.7.4 References

ARSD 74:51:01 – 74:51:03, "*South Dakota Administrative Rules*", Accessed September 9, 2008 at URL http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=74:51:01.

Boggs, J.M., 1983, "*Hydrogeologic Investigations at Proposed Uranium Mine Near Dewey, South Dakota*", Report no WR28-520-128, Tennessee Valley Authority.

Boggs, J.M., and Jenkins, A.M., 1980, "*Analysis of Aquifer Tests Conducted at the Proposed Burdock Uranium Mine Site, Burdock, South Dakota*", Report no. WR28-1-520-109, Tennessee Valley Authority.

Carter, J.M., Driscoll, D.G., and Hamade, G.R., 2001, "*Estimated Recharge to the Madison and Minnelusa Aquifers in the Black Hills Area, South Dakota and Wyoming, Water Years 1931-98*", U.S. Geological Survey Water-Resources Investigations Report 00-4278, 66 p.

Driscoll, D., Carter, J., and Williamson, J.E., 2002, "*Hydrology of the Black Hills Area, South Dakota*", U.S. Geological Survey Water-Resources Investigations, Report 02-4094, 158 pgs.

Flynn, K.M., Kirby, W.H., and Hummel, P.R., 2006, "*User's Manual for Program PeakFQ Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines*", U.S. Geological Survey, Techniques and Methods Book 4, Chapter B4; 42 pgs.

Galloway, J.M., 2000, "*Select Hydrogeologic Data for the Inyan Kara, Minnekahta, Minnelusa, Madison, and Deadwood Aquifers in the Black Hills Area, South Dakota*", USGS Open-File Report 99-602.

Gott, G.B., Wolcott, D.E., and Bowles, C.G., 1974, "*Stratigraphy of the Inyan Kara Group and Localization of Uranium Deposits, Southern Black Hills, South Dakota and Wyoming*", USGS Professional Paper 763, 63 p.

Hansen, E.M., Schreiner, L.C., and Miller, J.F., 1982, "*Hydrometeorological Report No. 52 – Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*", U.S. Department of Commerce and U.S. Department of the Army, Washington D.C., 168 pgs.

Hortness, J.E., and Driscoll, D.G., 1998, "*Streamflow Losses in the Black Hills of Western South Dakota*", U.S. Geological Survey Water-Resources Investigations Report 98-4116.

Jenkins, A.M., 1981, "*Burdock Mine Dewatering (Draft)*", Tennessee Valley Authority.

Johnson, B.N., 1933, "*A Climatological Review of the Black Hills*", The Black Hills Engineer, Rapid City, South Dakota School of Mines and Technology, 71 p.

Knight Piésold, 2008a., "*Pump Test Workplan, Dewey-Burdock In Situ Uranium Project*", April 25.

Knight Piésold, 2008b, "*2008 Pump Tests: Results and Analysis, Dewey-Burdock In Situ Uranium Project, Draft Report*", October 8, 2008.

Krantz, E., Larson, A. 2006, "*Upper Cheyenne River Watershed Assessment and TMDL: Fall River, Custer and Pennington Counties, South Dakota*", Unpublished.

Kyllonen, D.P., and Peter, K.D., 1987, "*Geohydrology and Water Quality of the Inyan Kara, Minnelusa, and Madison Aquifers of the Northern Black Hills, South Dakota and Wyoming, and Bear Lodge Mountains, Wyoming*", USGS Water-Resource Investigations Report 86-4158, pp. 66.

Miller, S.L., 2005, Influences of fractures and geologic structure on ground-water flow paths in the Mississippian Madison aquifer in the Rapid City area, South Dakota: Unpublished Ph-D Dissertation, South Dakota School of Mines and Technology, Rapid City, S.D.

Rao, A.R., and Hamed, K.H., 2000, "*Flood Frequency Analysis*", CRC Press.

RESPEC, 2008a. *Geological Characterization of the Dewey-Burdock Uranium Project, Fall River and Custer Counties, South Dakota*, RSI-2013, prepared by RESPEC, Rapid City, SD, for Powertech (USA) Inc., Edgemont, SD.

Ries, K.G., III, and Crouse, M.Y., 2002, "*The National Flood Frequency Program, Version 3: A Computer Program for Estimating Magnitude and Frequency of Floods for Ungaged Sites, 2002*", U.S. Geological Survey Water-Resources Investigations Report 02-4168, 42 p.

Sando, Steven, US Department of the Interior, US Geological Survey, "*Techniques for Estimating Peak-Flow*", GPO, 1998.

Schreiner, L.C., and Riedel, J.T., 1978, "*Hydrometeorological Report No. 51 – Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*", U.S. Department of Commerce and U.S. Department of the Army, Washington D.C. pp. 48-77.

SD DENR, 2002, "*The 2002 South Dakota Report to Congress*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

SD DENR, 2003, "*Standard Operating Procedures for Field Samplers Volume I – Tributary and Inlake Sampling Techniques*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

SD DENR, 2004, "*The 2004 South Dakota Integrated Report for Surface Water Quality Assessment*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

SD DENR, 2006, "*The 2006 South Dakota Integrated Report for Surface Water Quality Assessment*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

Strobel, M.L., Galloway, J.M., Hamade, G.R., and Jarrell, G.J., 2000, "*Potentiometric Surface of the Inyan Kara Aquifer in the Black Hills Area, South Dakota*", (map).

Strobel, M.L., Galloway, J.M., Hamade, G.R., and Jarrell, G.J., 2000, "*Potentiometric Surface of the Minnelusa Aquifer in the Black Hills Area, South Dakota*", (map).

2.8 Ecological Resources

2.8.1 Introduction

This section describes the existing ecological resources within the PAA. The analysis consisted of a review of existing local and regional documents, agency databases, and previous relevant reports, as well as targeted field surveys.

All vegetation sampling procedures were designed according to previous experience with similar projects and in collaboration with the South Dakota Department of Game, Fish and Parks (SDGFP).

Background information on terrestrial vertebrate wildlife species, and aquatic vertebrates and invertebrates in the vicinity of the project was obtained from several sources, including records from SDGFP, Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), and the original Draft Environmental Statement (DES) prepared by the Tennessee Valley Authority (TVA) in 1979. Site-specific data for the project and surrounding perimeter were obtained from those same sources, with current data collected during regular site visits and targeted surveys conducted from July 2007 through early August 2008.

2.8.2 Regional Setting

The PAA is within the mixed grass eco-region of the Northern Great Plains (EPA 1993), near the southwestern extension of the Black Hills. The elevation within the PAA ranges from approximately 3,600 feet to 3,900 feet above mean sea level, with the highest elevations along the pine breaks that overlap its eastern boundary. Topography in the PAA and surrounding lands is primarily gently rolling in the western quarter, with more varied terrain in the pine breaks and dissected hills that comprise the rest of the area.

The PAA is comprised of five main vegetative communities, in descending order: Ponderosa Pine Woodland, Big Sagebrush Shrubland, Greasewood Shrubland, Upland Grassland, and Cottonwood Gallery. Despite the overall ranking, Upland Grassland was present in the largest individual parcels. Interspersed among those primary habitats are smaller inclusions of Silver Sagebrush Shrubland, Agricultural Land, creek channels, and numerous ephemeral draws.

The PAA is located within the Cheyenne River watershed. Two main stream channels pass through the PAA: Beaver Creek (perennial) and Pass Creek (intermittent). Both flow south into the Cheyenne River, which runs from west to east approximately 2.5 miles south of the PAA boundary. A few small stock reservoirs are scattered throughout the area, though they may not retain water year-round.

Trees are present along the riparian corridors of both primary creeks, and on the higher elevation hilltops in the PAA. The plains cottonwood (*Populus deltoides*) was the only tree present along the creek channels, and was more prevalent in the Pass Creek corridor. Ponderosa pine (*Pinus ponderosa*) dominates the higher elevation hilltops and breaks in the central and eastern portions of the PAA, with Rocky Mountain juniper (*Juniperus scopulorum*) present as individual trees or small inclusions in some of the dry drainages.

2.8.3 Climate

The PAA is characterized as semi-arid continental or steppe with a dry winter season. The area commonly experiences low precipitation levels, high evaporation rates, low relative humidity, and plentiful sunshine. Temperatures are moderate, with large diurnal and annual variations, and extremes ranging from approximately -37 degrees F in the winter to 114 degrees F in the summer. The first freeze typically occurs in mid- to late September, with the last freeze often recorded during late May.

Yearly precipitation totals average about 14 inches. Approximately one-half of the annual precipitation falls during the months of May, June, and July. As expected, most of the winter precipitation occurs as snow, with an annual average of 37 inches. Thunderstorms are relatively frequent in the PAA during the summer months, averaging 40-45 days per year. Much of the annual rainfall is associated with these events.

Windy conditions are fairly common in the PAA, generally averaging 10 mph. Prevailing winds come from the west-northwest during much of the year, though east-southeast winds are also common.

2.8.4 Baseline Data

Ecological baseline studies for flora and fauna were collected to fulfill the objectives specified in U.S. Nuclear Regulatory Commission (NRC) NUREG-1569, "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications*". Ecological surveys were also conducted in accordance with applicable SD Department of Environment and Natural Resources (DENR), SDGFP, and USFWS established guidelines. These agencies were consulted prior to initiating field surveys to ensure that adequate objectives, survey methodologies, and data collection techniques were employed.

Vegetation sampling was conducted by BKS Environmental Associates, Inc. (BKS) of Gillette, Wyoming. Initial surveys were conducted during July 2007, with supplemental sampling performed to adjust to subsequent changes in the PAA boundary. Wildlife and aquatics sampling were conducted by ICF Jones & Stokes (formerly Thunderbird-Jones & Stokes), of Gillette, Wyoming from July 2007 through early August 2008 to meet agency requirements of one year of baseline data, and to accommodate changes to the PAA boundary during that period.

The following sections were generated from the final survey reports completed by BKS and Jones & Stokes for this project.

2.8.5 Terrestrial Ecology

Powertech (USA) conducted terrestrial ecological baseline field surveys including vegetation, wetlands, wildlife. The methodology and results are discussed in the following sections.

2.8.5.1 Vegetation

2.8.5.1.1 Survey Methodology

General

All sampling procedures were designed according to previous experience with similar projects, and the methodology was submitted to Powertech (USA) for its approval. Refer to Appendix 2.8-A for the submitted methodology.

Mapping

Seven different plant communities were identified for the PAA, i.e., Big Sagebrush Shrubland (BS), Greasewood Shrubland (GW), Ponderosa Pine Woodland (PP), Upland Grassland (UG), Cottonwood Gallery (CG), Silver Sagebrush Shrubland (SS), and Agricultural Land (AG), using 2001 color infra-red (CIR) aerial photography, which was verified by field survey. The Agricultural Land was not sampled as it was actively being used for crop production. The Silver Sagebrush Shrubland will be described as an inclusion of the Greasewood Shrubland Community.

Transect Origin Selection

The transects were randomly located in the field within each sampled vegetation community. Each transect was at least 150 feet from the previous transect. Random numbers between 1 and 360 were generated to determine cover transect direction, and compasses were utilized to orient transects to the nearest 1/8 of 360 degrees in the field. Each sample site was marked with hand-held Garmin Global Positioning System (GPS), and these points were later plotted on the final vegetation survey map (Plate 2.8-1).

Cover

A sample size of 37 50-meter point-intercept cover transects were sampled within the Ponderosa Pine Woodland and Greasewood Shrubland communities, while 27 samples were taken in the Big Sagebrush Shrubland, 26 samples for the Cottonwood Gallery and 30 samples for the Upland Grassland community for a total of 157 cover points in the PAA.

In the vegetation communities, each 50-meter transect represented a single sample point. Percent cover measurements were taken from point-intercepts at 1-meter intervals along a 50-meter transect. Transects that exceeded the boundaries of the vegetation community being sampled were redirected back into its vegetation community at a 90 degree angle from the original transect direction at the point of intercept. In instances where a 90 degree angle of reflection did not place the transect within the sampled community, a 45 degree angle of reflection was used. Each point-intercept represents 2 percent towards cover measurements.

Percent cover measurements record “first-hit” point-intercepts by live foliar vegetation species, litter, rock, or bare ground. Multiple hits on vegetation were recorded, but used only for the purpose of constructing a plant species list for each plant community (Appendix 2.8-B).

Total Vegetation Cover

Vegetation data cover was recorded by species, using first hit data. All point intercepts of living vegetation and growth produced during the current growing season were counted toward total vegetation cover. Total vegetation cover measurements were expressed in absolute percentages for each sample point. Percent vegetation cover is the vertical projection of the general outline of plants to the ground surface. Cover summaries for each vegetation community are contained in Appendix 2.8-C.

Total Ground Cover

Total ground cover data was recorded by live vegetation, litter, or rock, minus bare ground. Litter includes all organic material that is dead including manure. Rock fragments were recorded when equal to or greater than two centimeters in size (i.e., sheet flow, minimum non-erodible particle size). Total ground cover measurements were expressed in absolute percentages for each sample point. Total ground cover equals the sum of cover values for percent vegetation, percent litter, and percent rock.

Shrub Density

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data can be found in Appendix 2.8-C.

Shrub density data was collected in conjunction with randomly selected cover transects, wherever possible. All shrubs, full, half, or sub, were counted within 50 centimeters on either side of the 50 meter cover transect (1 meter x 50 meter belt transect), yielding a 100 m^2 belt transect. Sample adequacy was not calculated for shrub density. The number of belt transects equaled the number of cover transects for a given vegetation type.

Tree Density

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data can be found in Appendix 2.8-D.

Tree density data was collected in the Ponderosa Pine Woodland vegetation community in conjunction with randomly selected cover transects, wherever possible. Tree density in this community was determined using the point-center quarter method. Trees within the Cottonwood Gallery or Riparian areas were directly counted on an aerial photograph. Within other vegetation communities, individual *Pinus ponderosa* (Ponderosa Pine) or other tree species found were directly counted for numbers. Sample adequacy was not calculated on the point-center quarter plots.

Species Composition

A list of plant species encountered during 2007 quantitative sampling is compiled in Appendix 2.8-B by vegetation community type for each of the five vegetation communities. The species list includes plant species sampled in cover transects as well as plant species observed along the belt transect. Plant names in the Rocky Mountain Vascular Plants of Wyoming (Dorn 2001, 3rd Edition) were utilized. Plant identification was confirmed by Robert Dorn, when necessary. Scientific nomenclature followed that in use at the Rocky Mountain Herbarium in Laramie, Wyoming, during 2007.

Sample Adequacy

A minimum of 20 cover transects per vegetation type was sampled in five vegetation communities. Sample adequacy was calculated and an incremental number of cover transects was sampled up the maximum of 50.

The following sample adequacy formula was utilized to determine the minimum required size of the sample population.

$$n_{min} \geq \frac{2(sz)^2}{(dx)^2}$$

Where n_{min}= minimum number of sampled line transects needed to adequately represent native vegetation types
s= sample standard deviation
z= the z statistic
d= the amount of reduction desired
x= sample mean for cover

This sample adequacy formula is used by the Wyoming Department of Environmental Quality (WDEQ). The 2 in the numerator makes this a very conservative test. The term "grassland" indicates that a community has less than or equal to 20 percent relative cover by shrub species while a "shrubland" is greater than or equal to 20 percent relative cover by shrub species according to the WDEQ.

The five vegetation communities have been identified as “grassland”, or “shrubland”. Upland Grassland is identified as grassland while the Ponderosa Pine Woodland, Big Sagebrush Shrubland, Greasewood Shrubland, and Cottonwood Gallery communities are identified as shrublands. The constant values to be used in statistical tests for cover are: “z”=1.28 and “d” = 0.1 for grasslands and shrublands. All sampled vegetation was included in the sample adequacy test (i.e., “undesirable” species were not eliminated from the equation). Also as adjustments were made to the permit boundary, the samples that fell outside of the boundary were not excluded as they were initially part of the boundary at the time of survey.

Extended Reference Area

The Extended Reference Area (EXREFA) is a native land unit used to evaluate revegetation success on portions of the same native plant community that was affected by the proposed operation. This study shows the operation will affect five plant communities, Big Sagebrush Shrubland, Cottonwood Gallery, Greasewood Shrubland, Ponderosa Pine Woodland, and Upland Grassland. All areas of these communities not affected by production activities will serve as the EXREFA.

2.8.5.1.2 Vegetation Survey Results

The PAA acreage is 10,580 acres. Of these acres, Big Sagebrush Shrubland was 2,501.74 acres (23.70 percent), Greasewood Shrubland was 2,190.45 acres (20.75 percent), Ponderosa Pine Woodland was 2,183.76 acres (20.69 percent), Upland Grassland was 2,187.56 acres (20.72 percent), Agricultural Land was 780.79 acres (7.40 percent), Disturbed areas were 14.7 acres (0.14 percent), existing mine pits were 326.99 acres (3.10 percent), Cottonwood Gallery was 240.6 acres (2.28 percent), Silver Sagebrush Shrubland was 119.49 acres (1.13 percent), water was 8.94 acres (0.08 percent), and Shale Outcrop was 2.19 acres (0.02 percent). Refer to Table 2.8-1 for acreage of each vegetation community by permit acreage, and ½-mile buffer acreage.

Table 2.8-1: Acreage and Percent of Total Area for Each of the Map Units

Map Unit	Permit area	% of Area	1/2 Mile Buffer Area	% of Area
Sampled Vegetation Communities				
Big Sagebrush Shrubland	2,501.56	23.70	2,639.45	31.75
Greasewood Shrubland	2,190.45	20.75	837.66	10.07
Ponderosa Pine Woodland	2,183.76	20.69	2,036.58	24.49
Upland Grassland	2,187.56	20.72	2,027.18	24.38
Cottonwood Gallery	240.6	2.28	103.13	1.24
Described Vegetation Communities				
Agricultural Land	780.79	7.40	604.19	7.27
Disturbed	14.7	0.14	--	--
Existing Mine Permit	326.99	3.10	--	--
Silver Sagebrush Shrubland	119.49	1.13	53.65	0.65
Shale Outcrop	2.19	0.02	--	--
Water	8.94	0.08	12.6	0.15
TOTAL	**10,557.03**	**100.00**	**8,314.44**	**100.00**

General

The Extended Reference Area EXREFA will remain unaffected over the course of the proposed operation and will be used to evaluate revegetation success. The EXREFA will include portions of the same native plant communities that area affected by the proposed operation but located outside those disturbed areas and within the project boundary.

2.8.5.1.3 Big Sagebrush Shrubland

Cover

The Big Sagebrush Shrubland community comprised 2,501.56 of the 10,557.03 acres of the PAA (23.70 percent). Twenty-seven cover transects were sampled for this community. Absolute total vegetation cover was 45.89 percent. Absolute bare soil and litter/rock percentages were 14.07 percent and 38.52 percent, respectively. Absolute total ground cover was 85.78 percent. *Bouteloua gracilis* (blue grama), provided the highest relative vegetation cover at 24.38 percent, while *Buchloe dactyloides* (buffalograss) provided the next highest relative vegetation cover at 20.98 percent. Refer to Table 2.8-2 for the absolute cover values.

Table 2.8-2: 2007 Absolute Cover for the Big Sagebrush Shrubland Vegetation Community

Vegetation Parameter
Absolute Total Vegetation Cover (45.89%)
Absolute Total Cover (85.78%)

Sample Adequacy

There were 27 samples taken in the Big Sagebrush Shrubland plant community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Big Sagebrush Shrubland met sample adequacy

Refer to Table 2.8-3 below for sample adequacy values.

Table 2.8-3: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Big Sagebrush Shrubland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Big Sagebrush Shrubland						
Total Vegetation Cover	22.75	6.52	26.91	27.00	2.56	99.48
Total Ground Cover	42.64	3.49	2.20	27.00	8.98	NA

Shrub Density

Big Sagebrush Shrubland supported an average of 3,661.46 shrubs per acre or 0.90 shrubs/m^2. The following full and half/sub-shrub species were found: *Artemisia tridentata* (big sagebrush), *Artemisia frigida* (fringed sagewort), and *Gutierrezia sarothrae* (broom snakeweed). Refer to Appendix 2.8-D for a complete Big Sagebrush Shrubland density summary.

Species Composition

Species composition for the Big Sagebrush Shrubland community was dominated by warm season perennial grasses with 46.33 percent relative vegetation cover, followed by cool season perennial grasses with 20.33 percent relative vegetation cover. Perennial shrubs had 15.82 percent relative vegetation cover, while annual grasses had 10.15 percent relative vegetation cover . Annual forbs had 1.90 percent relative vegetation cover. Perennial forbs had 1.11 percent relative vegetation cover; sub-shrubs had a total of 2.59 percent relative vegetation cover. Succulents had 1.77 percent relative vegetation cover. The cool season perennial grasses were mainly *Elymus smithii* (western wheatgrass), *Carex filifolia* (threadleaf sedge), and *Poa secunda* (Sandberg bluegrass). The warm season perennial grasses were mainly blue grama, buffalograss, and *Bouteloua curtipendula* (sideoats grama). Annual grasses were *Bromus japonicus* (Japanese brome) and *Bromus tectorum* (cheatgrass). Perennial forbs were dominated by *Calochortus nuttallii* (sego lily), *Phlox spp.* (phlox), and *Sphaeralcea coccinea* (scarlet globemallow). Annual forbs included *Alyssum desertorum* (desert alyssum) and *Lepidium densiflorum* (prairie peppergrass). Present shrubs/sub-shrubs was big sagebrush, fringed sagewort, and broom snakeweed. Also present was the succulent *Opuntia polyacantha* (plains prickly pear). Refer to Table 2.8-4 for relative Big Sagebrush Shrubland cover summary and Appendix 2.8-C for a complete Big Sagebrush Shrubland cover summary.

Table 2.8-4: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Big Sagebrush Shrubland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	9.33	20.33
Warm Season Perennial Grasses	21.26	46.33
Annual Grasses	4.66	10.15
Annual Forbs	0.87	1.90
Perennial Forbs	0.51	1.11
Perennial Shrubs	7.26	15.82
Perennial Sub-Shrubs	1.19	2.59
Succulents	0.81	1.77

2.8.5.1.4 Greasewood Shrubland

Cover

The Greasewood Shrubland community comprised 2,190.45 of the 10,557.03 acres of the PAA (20.75 percent). Thirty-seven cover transects were sampled for this community. Absolute total vegetation cover was 37.11 percent. Absolute bare soil and litter/rock percentages were 18.70 percent and 42.54 percent, respectively. Absolute total ground cover was 81.41 percent. Western wheatgrass provided the highest relative vegetation cover at 23.31 percent. *Sarcobatus vermiculatus* (greasewood), provided the next highest cover at 22.88 percent. Refer to Table 2.8-5 for the absolute cover values.

Table 2.8-5: 2007 Absolute Cover for the Greasewood Shrubland Vegetation Community

Vegetation Parameter	**Mean**
Absolute Vegetation Cover (%)	37.11
Absolute Total Cover (%)	81.41

Sample Adequacy

There were 37 samples taken in the Greasewood Shrubland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Greasewood Shrubland met sample adequacy. Refer to Table 2.8-6 for sample adequacy values.

Table 2.8-6: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Greasewood Shrubland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Greasewood Shrubland						
Total Vegetation Cover	18.84	5.80	31.06	37.00	2.79	99.74
Total Ground Cover	40.70	6.74	8.99	37.00	5.19	NA

Shrub Density

Greasewood Shrubland supported an average of 2,589.42 shrubs per acre or 0.64 shrubs/m^2. The following full and half/sub-shrub species were found: greasewood, big sagebrush and *Artemisia cana* (silver sagebrush), *Ericameria nauseosa* (rubber rabbitbrush), and fringed sagewort. Refer to Appendix 2.8-D for a complete Greasewood Shrubland density summary

Species Composition

Species composition for the Greasewood Shrubland community was dominated by perennial shrubs with 28.70 percent relative vegetation cover, followed by cool season perennial grasses with 27.67 percent relative vegetation cover. Warm season perennial grasses had 24.31 percent relative vegetation cover. Annual grasses had 4.96 percent relative vegetation cover while annual forbs had 10.32 percent relative vegetation cover. Perennial forbs had 0.40 percent relative vegetation cover. Succulents had 3.64 percent relative vegetation cover. The cool season perennial grasses were mainly western wheatgrass, *Agropyron cristatum* (crested wheatgrass), threadleaf sedge, *Bromus inermis* (smooth brome), and *Elymus lanceolatus* (thickspike wheatgrass). Warm season perennial grasses were mainly blue grama, buffalograss, *Distichlis stricta* (inland saltgrass), and *Sporobolus airoides* (alkali sacaton). Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by scarlet globemallow, *Ambrosia psilostachya* (western ragweed), and *Convolvulus arvensis* (field bindweed). Annual forbs included *Bassia sieversiana* (summer cypress), *Plantago patagonica* (Pursh's plantain), and *Monolepis nuttalliana* (Nuttall's povertyweed). Shrubs included greasewood, big sagebrush and silver sagebrush. Plains prickly pear was also present. An area dominated by silver sagebrush was present within this community. This area was wetter than the typical greasewood community. The species composition was likely similar except for the dominance of silver sagebrush in the shrub component which is due to the increased moisture present within this area. Refer to Table 2.8-7 for relative Greasewood Shrubland cover summary and Appendix 2.8-C for a complete Greasewood Shrubland cover summary.

Table 2.8-7: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Greasewood Shrubland Community

	Vegetation Cover Absolute	Relative (%)
Cool Season Perennial Grasses	10.27	27.67
Warm Season Perennial Grasses	9.02	24.31
Annual Grasses	1.84	4.96
Annual Forbs	3.83	10.32
Perennial Forbs	0.15	0.40
Perennial Shrubs	10.65	28.70
Succulents	1.35	3.64

2.8.5.1.5 Ponderosa Pine Woodland

Cover

The Ponderosa Pine Woodland community comprised approximately 1,555.64 of the 7,960.77 acres of the PAA (19.54 percent). Thirty-seven cover transects were sampled for this community. Absolute total vegetation cover was 34.33 percent. Absolute bare soil and litter/rock percentages were 10.54 and 53.57, respectively. Absolute total ground cover was 88.92 percent. *Pinus ponderosa* (ponderosa pine) provided the highest relative vegetation cover at 45.03 percent, while *Carex geyeri* (Geyer's sedge) provided the next highest relative vegetation cover at 13.37 percent. Refer to Table 2.8-8 for the absolute cover values.

Table 2.8-8: 2007 Absolute Cover for the Ponderosa Pine Woodland Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	34.33
Absolute Total Cover (%)	88.92

Sample Adequacy

There were 37 samples taken in the Ponderosa Pine Woodland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Ponderosa Pine Woodland met sample adequacy. Refer to Table 2.8-9 below for sample adequacy values.

Table 2.8-9: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Ponderosa Pine Woodland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Ponderosa Pine Woodland						
Total Vegetation Cover	17.19	5.25	30.56	37.00	2.82	97.67
Total Ground Cover	44.19	3.86	2.50	37.00	3.80	NA

Shrub Density

Ponderosa Pine Woodland supported an average of 1,224.27 shrubs per acre or 0.30 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, silver sagebrush, rubber rabbitbrush, *Chrysothamnus viscidflorus* (Douglas rabbitbrush), fringed sagewort, broom snakeweed, *Rosa arkansana* (prairie rose), and *Yucca glauca* (yucca or small soapweed). Refer to Appendix 2.8-D for a complete Ponderosa Pine Woodland density summary.

Tree Density

Ponderosa Pine Woodland supported an average of 75.88 ponderosa pine trees per acre or 0.019 trees/m^2. *Juniperus scopulorum* (Rocky Mountain juniper) was also observed within this community; however no quantitative evaluations were made for this species. Refer to Appendix 2.8-E for a complete tree density summary for the Ponderosa Pine Woodland community.

Species Composition

Species composition for the Ponderosa Pine Woodland community was dominated by trees with 52.58 percent relative vegetation cover, followed by warm season perennial grasses with 22.34 percent relative vegetation cover. Cool season perennial grasses had 19.34 percent relative vegetation cover. Annual grasses had 0.79 percent relative vegetation cover while annual forbs had 0.44 percent relative vegetation cover. Biennial forbs had 0.15 percent relative vegetation cover, while perennial forbs had 1.22 percent relative vegetation cover. Succulents had 0.47 percent relative vegetation cover while perennial shrubs and sub-shrubs had 2.04 percent and 0.64 percent relative vegetation cover, respectively. The trees were dominated by ponderosa pine and *Juniperus scopulorum* (Rocky Mountain juniper). The cool season perennial grasses were mainly Geyer's sedge, western wheatgrass and *Hesperostipa comata* (needleandthread). Warm season perennial grasses were mainly blue grama, sideoats grama, *Schizachyrium scoparium* (little bluestem), and *Aristida purpurea var. fendleriana* (Fendler's threeawn). Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by *Erigeron spp.* (fleabane), *Thermopsis rhombifolia* (prairie thermopsis), *Antennaria parvifolia* (small-leaf pussytoes), *Liatris punctata* (dotted blazing star), and *Vicia americana* (American vetch). Annual forbs included *Chenopodium berlandieri* (pitseed goosefoot), *Draba nemorosa* (yellow draba), and *Lappula redowski* (beggars-tick). Biennial forbs included *Melilotus officinalis* (yellow sweetclover). The shrubs and subshrubs present were big sagebrush, silver sagebrush, and fringed sagewort. Plains prickly pear was also present. Refer to Table 2.8-10 for relative Ponderosa Pine Woodland cover summary and Appendix 2.8-C for a complete Ponderosa Pine Woodland cover summary.

Table 2.8-10: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Ponderosa Pine Woodland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	6.64	19.34
Warm Season Perennial Grasses	7.67	22.34
Annual Grasses	0.27	0.79
Annual Forbs	0.15	0.44
Biennial Forbs	0.05	0.15
Perennial Forbs	0.42	1.22
Perennial Shrubs	0.70	2.04
Perennial Sub-Shrubs	0.22	0.64
Succulents	0.16	0.47
Trees	18.05	52.58

2.8.5.1.6 Upland Grassland

Cover

The Upland Grassland community comprised approximately 2,187.56 of the 10,557.03 acres of the PAA (20.72 percent). Thirty cover transects were sampled for the Upland Grassland community. Originally there were 31 transects sampled in this community, however, upon review transect 26 was discarded due to the fact that it was not representative of the community. Absolute total vegetation cover was 46.02 percent. Absolute bare soil and litter/rock percentages were 11.07 and 41.13, respectively. Absolute total ground cover was 88.95 percent. Buffalograss provided the highest relative vegetation cover at 27.81 percent, while blue grama provided the next highest relative vegetation cover at 27.10 percent. Refer to Table 2.8-11 for the absolute cover values.

Table 2.8-11: Absolute Cover for the Upland Grassland Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	46.02
Absolute Total Cover (%)	88.47

Sample Adequacy

There were 30 samples taken in the Upland Grassland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Upland Grassland met sample adequacy. Refer to Table 2.8-12 for sample adequacy values.

Table 2.8-12: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Upland Grassland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Upland Grassland						
Total Vegetation Cover	23.00	6.88	29.32	30.00	1.29	90.15
Total Ground Cover	44.23	3.04	1.55	30.00	5.63	NA

Shrub Density

Upland Grassland supported an average of 51.01 shrubs per acre or 0.01 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, fringed sagewort, and broom snakeweed. Refer to Appendix 2.8-D for a complete Upland Grassland density summary.

Species Composition

Species composition for the Upland Grassland community was dominated by warm season perennial grasses with 54.91 percent relative vegetation cover, followed by cool season perennial grasses with 27.66 percent relative vegetation cover. Annual grasses had 9.00 percent relative vegetation cover, while annual forbs had 3.35 percent relative vegetation cover. Perennial forbs had 0.43 percent relative vegetation cover. Subshrubs had a total 0.15 percent relative vegetation cover. Succulents had 4.50 percent relative vegetation cover. The cool season perennial grasses were dominated by western wheatgrass, threadleaf sedge, and crested wheatgrass. Warm season grasses were dominated by blue grama and buffalograss. Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs included scarlet globemallow. Annual forbs included desert alyssum, prairie peppergrass, and *Thlaspi arvense* (field pennycress). Fringed sagewort was the only sub-shrub present. Also present was plains prickly pear. Refer Table 2.8-13 for relative Upland Grassland cover summary and to Appendix 2.8-C for a Upland Grassland complete cover summary.

Table 2.8-13: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Upland Grassland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	12.73	27.66
Warm Season Perennial Grasses	25.27	54.91
Annual Grasses	4.14	9.00
Annual Forbs	1.54	3.35
Perennial Forbs	0.20	0.43
Perennial Sub-Shrubs	0.07	0.15
Succulents	2.07	4.50

2.8.5.1.7 Cottonwood Gallery

Cover

The Cottonwood Gallery community comprised approximately 240.60 of the 10,557.03 acres of the PAA (2.28 percent). Twenty-six cover transects were sampled for the Cottonwood Gallery community. Absolute total vegetation cover was 62.61 percent. Absolute bare soil and litter/rock percentages were 1.19 and 17.50, respectively. Absolute total ground cover was 97.62 percent. Smooth brome provided the highest relative vegetation cover at 29.12 percent, while western wheatgrass provided the next highest relative vegetation cover at 26.29 percent. Refer to Table 2.8-14 for the absolute cover values.

Table 2.8-14: 2007 Absolute Cover for the Cottonwood Gallery Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	62.61
Absolute Total Cover (%)	97.62

Sample Adequacy

There were 26 samples taken in the Cottonwood Gallery community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Cottonwood Gallery met sample adequacy. Refer to Table 2.8-15 for sample adequacy values.

Table 2.8-15: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Cottonwood Gallery

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Cottonwood Gallery						
Total Vegetation Cover	31.31	7.65	19.56	26.00	2.95	99.84
Total Ground Cover	48.81	2.08	0.60	26.00	16.92	NA

Shrub Density

Cottonwood Gallery supported an average of 567.60 shrubs per acre or 0.14 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, silver sagebrush, rubber rabbitbrush, greasewood, and *Symphoricarpos occidentalis* (western snowberry). Refer to Appendix 2.8-D for a complete Cottonwood Gallery density summary.

Tree Density

Tree species within this community were counted on an aerial photograph. Upon counting the number of plains cottonwoods within the community was 295.

Species Composition

Species composition for the Cottonwood Gallery community was dominated by cool season perennial grasses with 55.41 percent relative cover, followed by trees with 21.37 percent relative cover. Warm season perennial grasses had 0.37 percent relative cover. Annual forbs had 18.06 percent relative cover while annual grasses had 1.23 percent relative cover. Perennial forbs had 2.33 percent relative cover. Shrubs had a total 1.23 percent relative cover. The cool season perennial grasses were dominated by smooth brome and western wheatgrass. The warm season perennial grasses included inland saltgrass. Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by *Cirsium arvense* (Canada thistle) and *Achillea millefolium* (common yarrow). Annual forbs included summer cypress and *Chenopodium album* (lambsquarters goosefoot). Present shrubs were silver sagebrush, greasewood, and *Symphoricarpos occidentalis* (western snowberry). *Populus deltoides* (plains cottonwood) was the only tree present. Refer to Table 2.8-16 below for relative Cottonwood Gallery cover summary and to Appendix 2.8-C for a Cottonwood Gallery complete cover summary.

Table 2.8-16: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Cottonwood Gallery Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	34.69	55.41
Warm Season Perennial Grasses	0.23	0.37
Annual Grasses	0.77	1.23
Annual Forbs	11.31	18.06
Perennial Forbs	1.46	2.33
Perennial Shrubs	0.77	1.23
Trees	13.38	21.37

2.8.5.1.8 Vegetation Survey Discussion

The proposed 10,580 acre PAA consists of five vegetation communities: Big Sagebrush Shrubland, Greasewood Shrubland, Ponderosa Pine Woodland, Upland Grassland, and Cottonwood Gallery. Each community was investigated for baseline vegetation information in support of a NRC Source Materials License and SD DENR Regular Mine Permit Application.

No threatened or endangered species were encountered within the PAA. The presence of the state designated weed Canada thistle was present within the Cottonwood Gallery vegetation community. The presence of the Fall River County designated weed field bindweed was present within the Greasewood Shrubland vegetation community.

2.8.5.2 Wetlands

2.8.5.2.1 Wetland Survey Methodology

The wetland surveys were conducted in accordance with the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region. All WoUS and OWUS were assessed during the surveys. The routine wetland delineation approach with onsite inspection was utilized, and the survey was conducted by pedestrian reconnaissance and review of existing maps of the PAA. Identification of potential wetlands was based on visual assessment of vegetation and hydrology indicators, as well as intrusive soil sampling to determine the presence of wetland criteria indicators. Wetland Determination Data Forms-Great Plains Region (DRAFT), were utilized for each observation point. Hydrology and soils were evaluated whenever a plant community type met hydrophytic vegetation parameters based on the Dominance Test and Prevalence Index (as defined by the Great Plains Regional Supplement), or whenever indicators suggested the potential presence of a seasonal wetland area under normal circumstances.

Figure 2.8-1 below identifies Beaver Creek, Figure 2.8-2 identifies the Cottonwood Gallery, and Figure 2.8-3 identifies the concentration of old mine pits.

Powertech (USA) Inc.

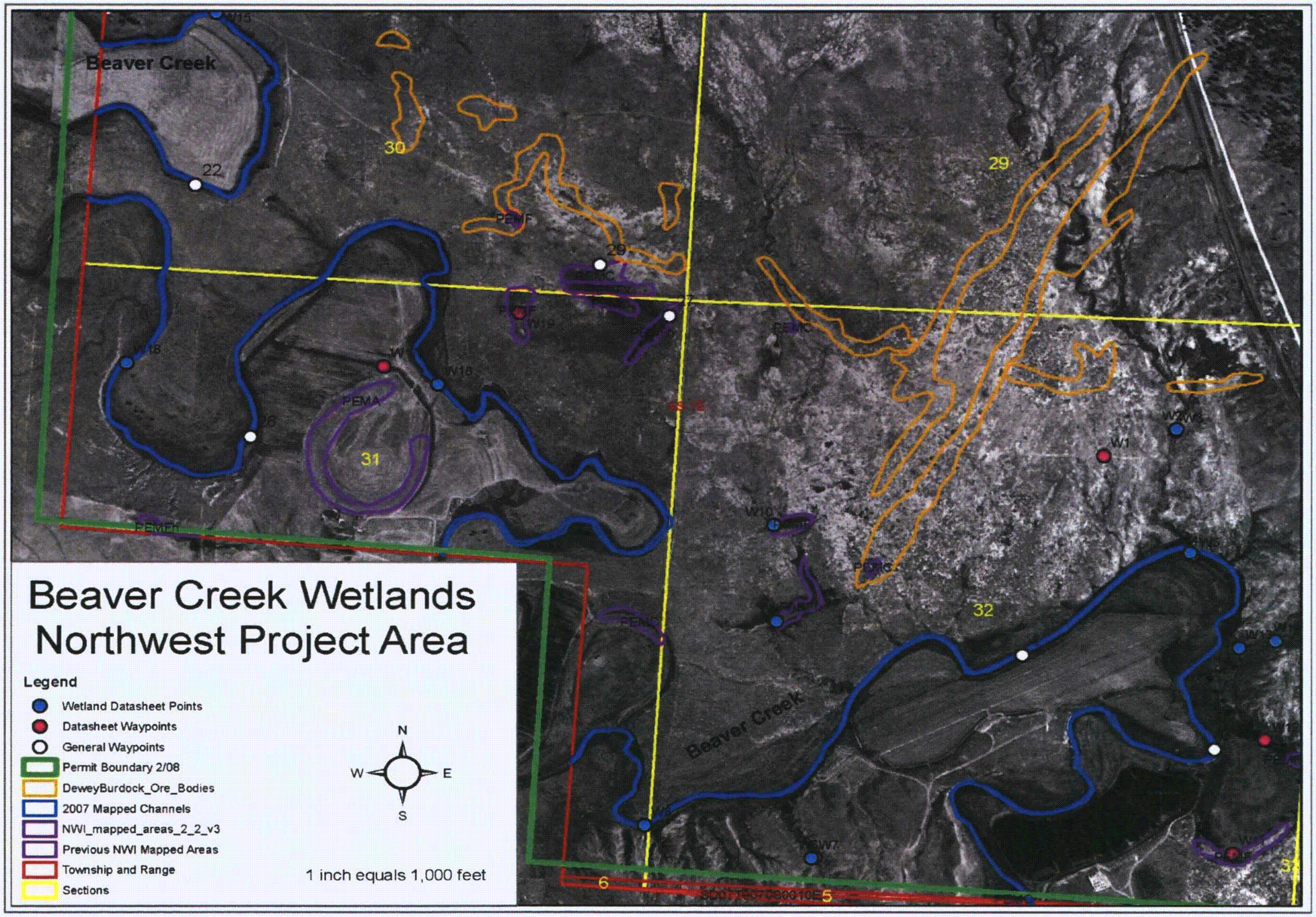


Figure 2.8-1: Beaver Creek Wetlands Northwest Project Area

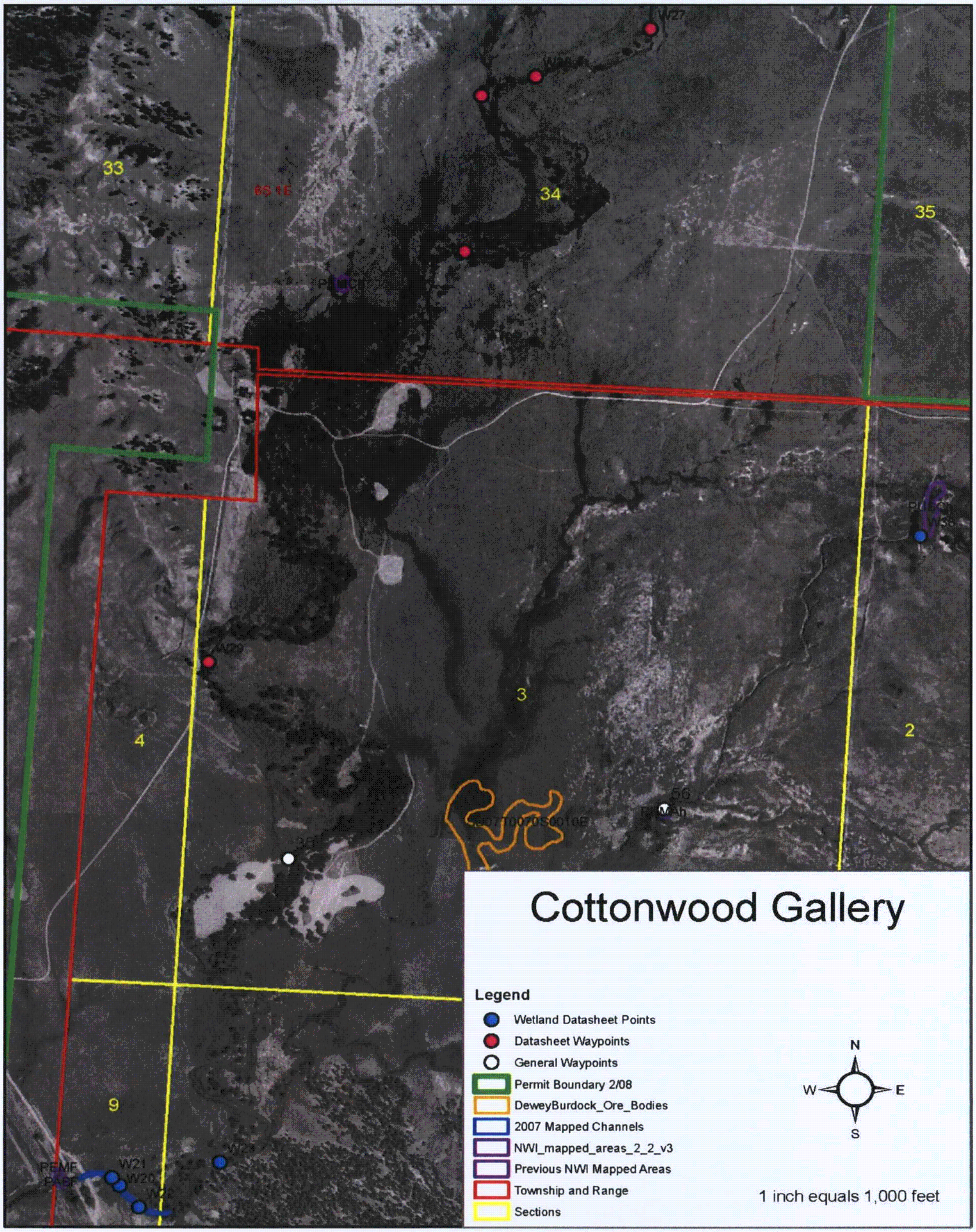


Figure 2.8-2: Cottonwood Gallery

POWERTECH (USA) INC.

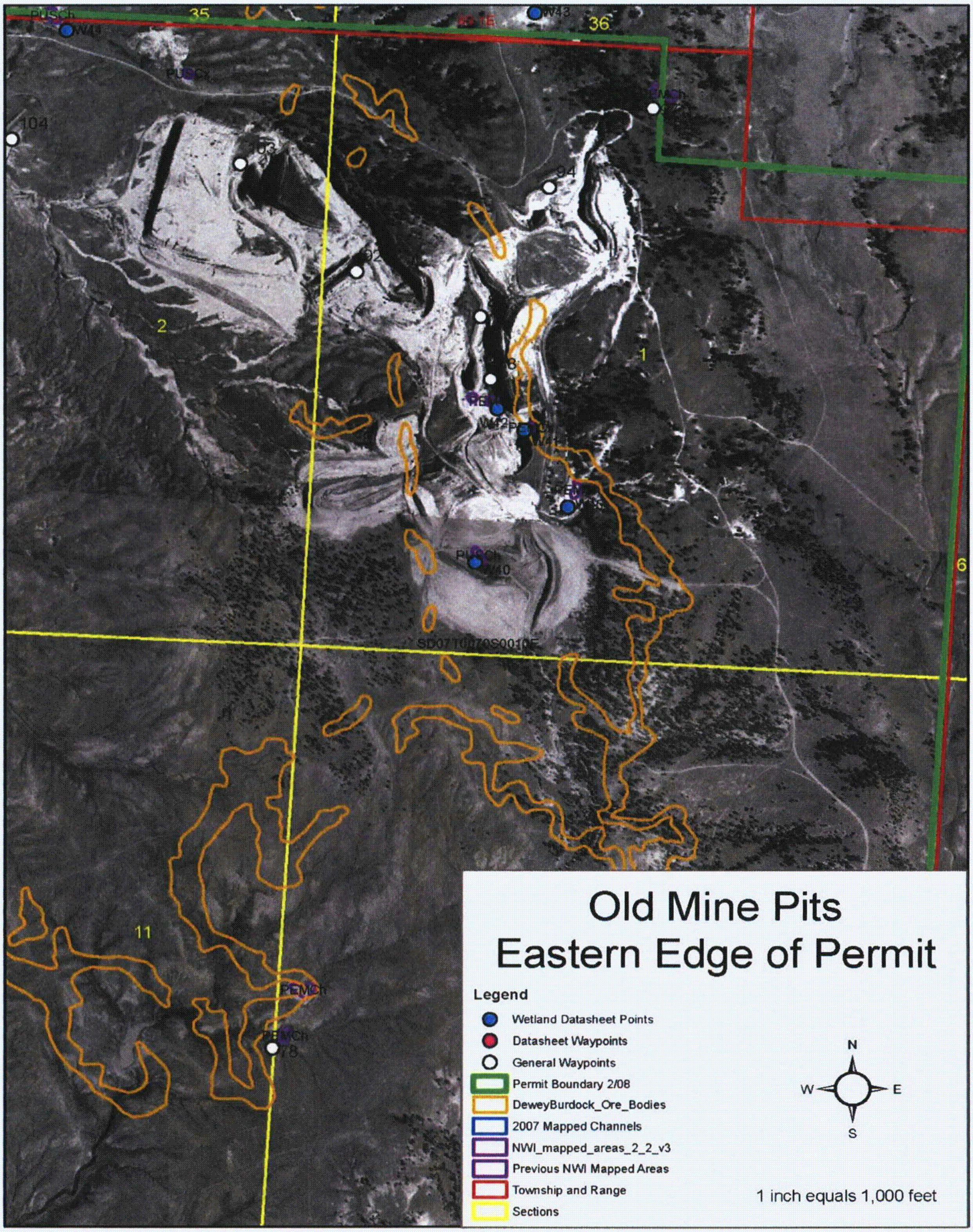


Figure 2.8-3: Old Mine Pits Eastern Edge of Permit

Natural Resources Conservation Service (NRCS) soils mapping for Custer and Fall River Counties, South Dakota, (2007) and BKS soil mapping of the PAA were reviewed for general soils information.

Potential wetlands (WoUS) and OWUS were initially identified via review of area maps to include the following:

- 1977 USFWS NWI mapping for the Dewey, Burdock and Twenty-one Quads
- Custer Quad Digital Elevation Model
- Burdock Quad Digital Elevation Model

Wetland indicator categories were identified for each dominant plant species noted through use of the National List of Vascular Plant Species that Occur in Wetlands, 1996 National Summary. Region 4 (North Plains) indicator categories were utilized for the PAA.

Field sample locations and resulting wetland boundaries were recorded with a hand-held Garmin GPS map 60Cx Global Positioning System (GPS) unit in NAD 1983 UTM Zone 13. BKS provided drafting services for the project.

2.8.5.2.2 Wetland Survey Results

The PAA was generally characterized by Big Sagebrush Shrubland, Greasewood Shrubland, and Ponderosa Pine Woodland with pockets of Upland Grassland and Agricultural land, mine pit, Silver Sagebrush Shrubland, Shale Outcrop, or Pass Creek. Beaver Creek had Agricultural land to the south and Greasewood Shrubland and Big Sagebrush Shrubland to the north. Agricultural land comprised 399.83 acres, Greasewood Shrubland comprised 2,252.15 acres and Big Sagebrush Shrubland comprised 2,738.85 acres. Beaver Creek had water present continuously in the drainage and wetland species near the banks. The upper banks were comprised mainly of *Artemisia tridentata* (big sagebrush), *Sarcobatus vermiculatus* (Greasewood), and *Elymus smithii* (Western wheatgrass). The wetland indicator status of these plants are UPL (upland), UPL, and FACU (facultative upland) respectively. The Pass Creek comprised of the Cottonwood Gallery vegetation community comprised mainly of *Bromus inermis* (smooth brome), western wheatgrass, and *Populus deltoides* (cottonwood trees). The wetland indicator statuses of these plants are UPL, FACU, and FAC (facultative) respectively. Please refer to Section 2.8.5.1 for further information regarding the vegetation within the PAA.

The PAA generally occurs on uplands, with inclusions of two main drainages, Beaver Creek and Pass Creek and several depressed areas. Beaver Creek and Pass Creek were evaluated using pedestrian reconnaissance, while the remaining small drainages were evaluated based on existing mapping. Wetlands were identified throughout the Beaver Creek drainage; however Pass Creek only had wetlands present near an old open flowing well close to the project boundary. Wetlands were also identified in the majority of the old mine pits as well as depressed areas throughout the PAA. The wetland classification along Beaver Creek was Riverine Lower Perennial Emergent (R2EM) and Palustrine Emergent (PEM) WoUS inPass Creek and other small drainages. The mine pits were primarily designated as Palustrine Unconsolidated Bottom (PUB) OWUS and depressions were typically PEM or PUB designations.

The proposed project may affect a total of 35.114 acres of R2EM, R4SB7 (Riverine Intermittent Streambed vegetated), and PEM stream channel, Palustrine Aquatic Bed Intermittently Flooded Diked (PABJh), Palustrine Unconsolidated Shore Temporarily Flooded (PUSA), PEM, PUB, PUS, and PEMC (seasonally flooded) isolated ponds, and open water (OW). The acreage of OW consists of approximately 9.451 acres.

The area had previously been mined for uranium through several open pit mines; some of the mines had been filled in with water. One livestock watering tank was identified on the survey.

Soils information for the PAA was obtained by NRCS Web Soil Survey for Custer and Fall River Counties, South Dakota, (2007).

There are two main drainage basins located in the PAA; each of the drainages had different soil types. Beaver Creek had Haverson loam, 0-2 percent slopes throughout the drainage. Pass Creek had Barnum silt loam in the south half of the drainage and Barnum-Winetti complex, 0-6 percent slopes. The old mine pits were also classified as Barnum silt loam and Barnum-Winetti complex.

None of the soil map units were found on the hydric soils list for Fall River County or Custer County, South Dakota.

Table 2.8-17 is a summary list of the wetlands in the PAA along with several details about each wetland, including location, delineation designation, geomorphic setting, comments, and jurisdictional recommendations. Table 2.8-18 provides of summary of the 2007 wetland delineation results.

Table 2.8-17: Summary of Wetlands within the Proposed Action Area

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W1	Sec 32 T6S R1E	R1 P1	Wetland	PEMC	0.005	Depression in tributary	--	Non-jurisdictional
W2	Sec 32, T6S R1E	No photos	Wetland	R2EM	0.017	Tributary to Beaver Creek, wetland channel	--	Jurisdictional
W3	Sec 32, T6S R1E	R1 P12 R1 P13	Non-wetland	--	--	Tributary to Beaver Creek	--	--
W4	Sec. 32, T6S R1E	R1 P2 R1 P3 R1 P4	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W5	Sec 32, T6S R1E	R1 P5	Non- wetland	--	--	Drainage	Bank of Beaver Creek	--
W6	Sec. 32, T6S R1E	R1 P16	Non-wetland	--	--	Upland tributary	--	--
W7	Sec. 32, T6S R1E	R1 P17 R1 P18	Wetland	R4SB7	0.002	Upland tributary, wetland channel	--	Non-jurisdictional
W8	Sec. 31, T6S R1E	R1 P19 R1 P20	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W9	Sec. 32, T6S R1E	R1 P23 R1 P24	Wetland	PABJh	0.26	Depression w/ berm	Previously mapped as PABFh	Non-jurisdictional
W10	Sec. 32, T6S R1E	R2 P1 R2 P2	Wetland	PUSA	0.03	Depression	Previously mapped as PEMF	Non-jurisdictional
W11	Sec. 32 T6S R1E	R2 P3 R2 P4	Non-wetland	--	--	Drainage by berm	Previously mapped as PEMF	--
W12	Sec. 32 T6S R1E	R2 P5 R2 P6	Non-wetland	--	--	Drainage	Previously mapped as PEMF	--
W13	Sec. 32 T6S R1E	No photos	Wetland	R4US	0.036	Drainage, wetland channel	Beaver Creek	Jurisdictional
W14	Sec. 32 T6S R1E	R2 P7 R2 P8 R2 P9	Wetland	R4US	0.012	Isolated Drainage, wetland channel	Tributary	Non-jurisdictional
W15	Sec. 30 T6S R1E	R2 P12 R2 P13	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W16	Sec. 31 T6S R1E	R2 P18 R2 P19	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (cont'd)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W17	Sec. 31 T6S R1E	R2 P22 R2 P23	Non-Wetland	--	--	Ditch around Agricultural area	Previously mapped as PEMA	--
W18	Sec. 31 T6S R1E	R3 P1 R3 P2	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W19	Sec. 31 T6S R1E	R3 P3 R3 P4	Non-wetland	--	--	Low area	Previously mapped as PEMF	--
W20	Sec. 9 T7S R1E	R3 P8 R3 P9	Wetland	PEM	0.503	Drainage, wetland channel	Pass Creek	Non-jurisdictional
W21	Sec. 9 T7S R1E	R3 P10 R3 P11 R3 P12	Wetland					
W22	Sec. 9 T7S R1E	R3 P13 R3 P14	Wetland					
W23	Sec. 10 T7S R1E	R3 P17 R3 P18	Wetland					
W25	Sec. 34 T6S R1E	R4 P1 R4 P2	Non-wetland	--	--	Drainage	Pass Creek	--
W26	Sec. 34 T6S R1E	R4 P3 R4 P4	Non-wetland	--	--	Drainage	Pass Creek	--
W27	Sec. 34 T6S R1E	R4 P11 R4 P12	Non-wetland	--	--	Drainage	Pass Creek	--
W28	Sec. 34 T6S R1E	R4 P13 R4 P14	Non-wetland	--	--	Drainage	Pass Creek	--
W29	Sec. 3 T7S R1E	R4 P17 R4 P18	Non-wetland	--	--	Drainage	Pass Creek	--
W30	Sec. 10 T7S R1E	R4 P19 R4 P20	Non-wetland	--	--	Depression	--	--
W31	Sec. 10 T7S R1E	R4 P21 R4 P22	Wetland	PUB	1.801	Depression	--	Non-jurisdictional
W32	Sec. 10 T7S R1E	R4 P24 R4 P25	Wetland	PUB	1.475	Depression	--	Non- jurisdictional
W33	Sec. 14 T7S R1E	R5 P1 R5 P2	Wetland	PEM	1.417	Pond	--	Non- jurisdictional
W34	Sec. 14 T7S R1E	R5 P9 R5 P10	Non-wetland	--	--	Drainage	--	--

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (cont'd)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W35	Sec. 14 T7S R1E	R5 P11 R5 P12	Wetland	PUB	1.972	Depression	--	Non-jurisdictional
W36	Sec. 10 T7S R1E	R5 P20 R5 P21	Wetland	PEM	0.253	Outfall	Drainage	Non-jurisdictional
W37	Sec. 34 T6S R1E	R6 P6 R6 P7 R6 P8 R6 P9 R6 P10	Non-wetland	OW	7.635	Old Mine Pit	--	--
W38	Sec. 2 T7S R1E	R6 P13 R6 P14	Wetland	PUS	1.099	Depression	--	Non-jurisdictional
W39	Sec. 2 T7S R1E	R6 P16 R6 P17	Wetland	PUS	0.308	Depression w/ manmade berm	--	Non-jurisdictional
W40	Sec. 1 T7S R1E	R6 P18	Wetland	PEM	0.213	Pond	--	Non-jurisdictional
W41	Sec. 1 T7S R1E	R6 P19 R6 P20	Wetland	PUB	0.008	Old Mine Pit	--	Non-jurisdictional
W42	Sec. 1 T7S R1E	R6 P22 R6 P23 R6 P24	Wetland	PUB	0.167	Old Mine Pit	--	Non-jurisdictional
W43	Sec. 36 T6S R1E	Outside of PAA, deleted photographs from Appendix 2.8-F and datasheet from Appendix 2.8-G						
W44	Sec. 2 T7S R1E	R7 P24 R8 P1 R8 P2	Wetland	PEM	0.378	Depression near drainage	--	Non-jurisdictional
W45	Sec. 1 T7S R1E	R8 P4 R8 P5	Wetland	PEM	0.035	Depression	--	Non-jurisdictional
Wpt 3	Sec. 32 T6S R1E	R1 P6 R1 P7	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 4	Sec. 32 T6S R1E	R1 P8 R1 P9	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 22	Sec. 30 T6S R1E	R2 P14 R2 P15	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (cont'd)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
Wpt 26	Sec. 31 T6S R1E	R2 P24	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 27	Sec. 31 T6S R1E	R3 P5	Non-wetland	--	--	Depression	Previously mapped as PEMFh, no longer present	--
Wpt 29	Sec. 30 T6S R1E	R3 P6 R3 P7	Non-wetland	--	--	Depression	Previously mapped as PEMC and PEMFx, no longer present	--
Wpt. 35	Sec. 3 T7S R1E	R3 P23 R3 P24	Non-wetland	--	--	Drainage	Cottonwood Drainage	--
Wpt. 56	Sec. 3 T7S R1E	R5 P3 R5 P4	Non-wetland	--	--	Depression	Previously mapped as PEMAf- not present	--
Wpt. 57	Sec. 14 T7S R1E	R5 P5	Non-wetland	--	--	Depression	--	--
Wpt. 58	Sec. 14 T7S R1E	R5 P8	Wetland	PEM	1.417	Pond	Same as W33	Non- jurisdictional
Wpt. 60 and Wpt. 61	Sec. 15 T7S R1E	R5 P13 R5 P14 R5 P15	Non-wetland	--	--	Depression	Salt Crust present	--
Wpt. 62	Sec. 10 T7S R1E	R5 P16 R5 P17	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present	
Wpt. 68	Sec. 10 T7S R1E	R5 P18 R5 P19	Wetland	PEM	0.253	Outfall	Same as W36	Non-jurisdictional
Wpt. 74	Sec. 11 T7S R1E	R6 P1 R6 P2	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present	
Wpt. 78	Sec. 12 T7S R1E	R6 P5	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present. Nor the PEMCh just north of the point.	

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (concl.)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
Wpt. 83	Sec. 2 T7S R1E	R6 P15	Wetland	PUS	0.308	Depression w/ manmade berm	Same as W39	Non-jurisdictional
Wpt. 88 and Wpt. 89	Sec. 1 T7S R1E	R7 P1 R7 P2	Non-wetland	--	--	Old Mine Pit	Dominated by rabbit brush and *Hordeum jubatum*	--
Wpt. 92	Sec. 1 T7S R1E	R7 P5 R7 P6 R7 P7	Non-wetland	OW	0.452	Old Mine Pit	Mine Pit filled with water	--
Wpt. 94	Sec. 1 T7S R1E	R7 P9	Non-wetland	--	--	Old Mine Pit	Mine pit is dry, no vegetation	--
Wpt. 97	Sec. 1 T7S R1E	R7 P14	Non-wetland	--	--	Depression	Previously mapped PEMCh not present	--
Wpt 103	Sec. 2 T7S R1E	R7 P20	Wetland	PEM and OW	2.364	Old Mine Pit	--	Non-jurisdictional
Wpt 104	Sec. 2 T7S R1E	R7 P21 R7 P22 R7 P23	Wetland	PUS	1.299	Depression	--	Non-jurisdictional

Table 2.8-18: Summary of 2007 Wetland Delineation Results

Summary		
Number of Features	**Name**	**Acres**
2	Wetland Channel (PEM)	0.756
2	Wetland Channel (R2EM)	13.393
1	Wetland Channel (R4SB7)	0.002
2	Wetland Channel (R4US)	0.048
4	PEM Isolated Ponds	2.043
1	PEMC Isolated Pond	0.005
1	PABJh Isolated Ponds	0.260
1	PUSA Isolated Ponds	0.030
3	PUB Isolated Depression	5.248
3	PUS Isolated Depression	2.706
5	Mine Pits PUB, PEM, OW	10.626
	Total	**35.114**
	Wetland Channel (PEM)	1,842.05 Linear Feet (0.35 mi)
	Wetland Channel (R2EM)	34,079.65 Linear Feet (6.45 mi)

Results:

Beaver Creek

Beaver Creek is located in the northwest of the PAA in Sections 30, 31, and 32 in T6S, R1E. The entire stretch of Beaver Creek within the project boundary is designated as a R2EM wetland, for a total of 13.376 acres. Seven data forms were filled out for the variety of lengths in the drainage as well as four photo waypoints. The most common vegetation that was identified along the drainage was *Spartina pectinata* (prairie cordgrass), *Juncus balticus* (Baltic rush), and *Schoenoplectus pungens* (common threesquare). These plants have an indicator status of FACW (facultative wet), FACW, and OBL (obligate) respectively.

Pass Creek

Pass Creek is centrally located within the PAA in T7S, R1E in Sections 3, 9, and 10, and T6S, R1E in Section 34. Pass Creek only had wetlands present in Section 9, primarily due to an old open flowing well on the other side of the road outside the project boundary. The wetland totaled 0.503 acres of PEM, a total of four datasheets were filled out. The common vegetation found within the wetland was prairie cordgrass and common threesquare. The remaining drainage was walked and delineated, however no other wetlands were present. Five non-wetland datasheets were filled out and photo points were taken. Refer to Table 2.8-17, Summary of Wetlands within the PAA for more details.

Previously Mapped Wetlands Confirmed as a Non-Wetland

There were several National Wetlands Inventory 1977 previously mapped wetlands that were confirmed as non-wetland or not present during the 2007 field survey. The areas generally lacked hydrophytic vegetation, hydric soils, and hydrology. Most areas had geomorphic position but often lacked another secondary indicator. Datasheets were filled out to confirm no presence of these wetlands and can be found in Table 2.8-17, Summary of Wetlands within the PAA for more details. Previously mapped wetlands that are no longer present do not appear on the map (Plate 2.8-2).

Old Mine Pits

There are seven old uranium open pits present within the PAA. Four of the mine pits were classified as non-wetland primarily due to lack of hydrophytic vegetation and/or hydrology presence. Two mine pits located in T7S, R1E in Section 1 were classified as PUB wetlands. The only mine pit in Section 2 was classified as both a PEM and Open Water (OW). The PEM is located along the bank of the pit and OW throughout the rest of the pit. The mine pit in Section 34 T6S R1E was classified as OW and totaled 7.635 acres another small mine pit located at waypoint 92 is Section 1 T7S R1E was classified as OW at 0.452 acres. There were approximately 1.172 acres of wetlands and 9.451 acres of open water within old mine pits in the PAA. Refer to Table 2.8-17, Summary of Wetlands within the PAA for more details.

Depressional Areas and Ponded Areas Identified as Wetlands

All the depressional areas identified as wetlands in 2007 were also previously identified during the 1977 NWI mapping. All of these wetlands are recommended to be non-jurisdictional based on the isolated nature of the wetlands. The wetlands were primarily classified as PEM, PEMC, PABJh, PUS, PUSA and PUB wetlands based primarily on the hydrology conditions of each waypoint. There were approximately 10.292 acres of wetland depressions and ponds present within the PAA. Refer to Table 2.8-17, Summary of Wetlands within the PAA for more details.

Expanded Boundary Analysis

Surveys for wetlands were conducted inside the buffer boundary and not inside the expanded boundary.

Beaver Creek Update

Beaver Creek is likely to have wetlands throughout the entire PAA as it is a major drainage and had a good flow of water when the surveys were conducted in 2007. The boundary change took out 1.956 acres of R2EM wetlands along Beaver Creek in the NW1/4 of Section 31 T6S R1E. The boundary change also added 4.81 acres of R2EM wetlands along Beaver Creek in the SE1/4 of Section 31 T6S R1E and E1/2 of Section 5, the SW1/4 of Section 4 of T7S R1E. The total acreage addition to the wetlands along Beaver Creek was 2.86 acres of R2EM.

Small PEM and PUB isolated wetlands may be found SW of the Beaver Creek Drainage is Section 5, T7S R1E; however accessibility to the area was not present to confirm. There are two depressions that can be seen on the map and based on the 2007 surveys of the PAA the likelihood of the depressions being classified as a wetland is rare.

Pass Creek Update

In 2007, Pass Creek had 0.503 acres of PEM wetlands surveyed along its stretch; however due to the recent boundary change there are now only 0.05 acres of wetlands present on Pass Creek. The boundary change moved the boundary east of W22, and now excludes the three wetland points of W20, W21, and W22. The wetlands present on Pass Creek are primarily due to an old open flowing well on the other side of the road outside the project boundary.

In 2007, Pass Creek was surveyed from the southern project boundary to the old mine pit and no wetlands were identified except near the spring. No surveys were conducted on Pass Creek in 2008 as the map indicated that the area is likely dry.

Old Mine Pits

No changes to the acreages on the 2007 identified old mine pits wetland occurrences.

Depressional Areas and Ponded Areas Identified as Wetlands

No changes to the acreages on the 2007 depressional areas and ponded areas identified as wetlands. As noted above there may be some isolated PUB or PEM depressional areas SW of Beaver Creek, but accessibility to the area was not present during the 2008 surveys. However, it is unlikely that the areas indicated contain wetlands as the 2007 surveys proved that many of the potential wetlands indicated on the map and NWI no longer existed.

2.8.5.3 References

Dorn, R.D., 2001, "Vascular Plants of Wyoming, 3rd Edition", Mountain West Publishing, Cheyenne, Wyoming. 289 pp.

U.S. Army Corps of Engineers. (20??). "Interim Regional Supplement to the corps of Engineers Wetland Delineation Manual: Great Plains Region," J.S. Wakeley, R.W. Lichvar, and C.V. Noble, eds., Technical Report_____, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Natural Resource Conservation Service. 2007. Web Soil Survey. http://websoilsurvey.nrcs.usda.gov/app/ May 21, 2007

U.S. Fish and Wildlife Service. 1997. National List of Vascular Plant Species that Occur in Wetlands: 1996 National Summary.

Wyoming Game and Fish. 2007. National Wetlands Inventory Mapping from 1976.

2.8.5.4 Wildlife

2.8.5.4.1 General Setting

This section provides a general discussion of the affected environment for vertebrate terrestrial wildlife and aquatic species (vertebrates and macro-invertebrates). Background information for terrestrial and aquatic fauna in the vicinity of the project was obtained from several sources, including records from SDGFP, BLM, USFWS, USFS, and the TVA DES for similar operations overlapping the PAA. Site-specific data for the project and surrounding perimeter were obtained from those same sources, with current data collected during regular site visits and targeted surveys conducted for this project.

Survey protocols and timing were developed collaboratively with SDGFP to meet species-specific requirements. The survey area included the PAA and one-mile perimeter for threatened and endangered (T&E) species, bald eagle winter roosts, all nesting raptors, upland game bird leks, and big game. Surveys conducted only in the PAA included other vertebrate species of concern tracked by the South Dakota Natural Heritage Program (SDNHP), as well as bats, small mammals, lagomorphs, prairie dog (*Cynomys* spp.) colonies, breeding birds, predators, and herptiles (reptiles and amphibians). Aquatic sampling occurred at water gauge stations located in Beaver Creek upstream of the PAA, and in Beaver Creek and the Cheyenne River downstream of the area. In addition to these targeted efforts, incidental observations of all vertebrate wildlife species seen within the PAA were recorded during each site visit during the year-long baseline survey period. Surveys for black-footed ferrets (*Mustela nigripes*) were not required for this project due to a block clearance issued by the USFWS that includes the entire PAA and vicinity. All surveys were conducted by qualified biologists using standard field equipment and appropriate field guides. Most observations were recorded from vantage points during pedestrian or vehicular surveys to avoid disturbing wildlife; exceptions included small mammal trapping and aquatic species sampling. Raptor nests, prairie dog colonies, and other features or observation points of special interest were mapped in the field using a hand-held Global Positioning System (GPS) receiver to record the Universal Transverse Mercator (UTM, NAD27) coordinates.

2.8.5.4.2 Big Game

No crucial big game habitats or migration corridors are recognized by the SDGFP in the PAA or surrounding one-mile perimeter. Crucial range is defined as any particular seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level.

Pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) are the only two big game species that regularly occur in the PAA, and both are considered year-round residents. Elk (*Cervus elaphus*) and white-tailed deer (*O. virginianus*) are also present in the survey area, but only in small herds. The latter two species can also be seen in the survey area year-round, but may be more common during different times of the year.

The pronghorn is the most common big game species in the project survey area, though no species is prevalent. The pronghorn is a browse species and sagebrush-obligate, using shrubs for both forage and cover (Fitzgerald et al. 1994). Pronghorn herds were most often observed in sagebrush stands just beyond the north-central boundary of the PAA during winter 2007-2008. Conversely, herds were widely distributed throughout grassland habitats in the northwestern and southeastern portions of the survey area during spring, summer, and early fall 2008. In June, after the ground and water pools had dried up, water availability became a limiting factor and pronghorn began to move to, and concentrate around, more dependable water sources such as Beaver Creek and livestock tanks, and to draws with more succulent forage.

Mule deer use nearly all habitats, but prefer sagebrush-grassland, rough breaks, and riparian bottomland (Jones et al. 1983). Browse is an important component of the mule deer's diet throughout the year, comprising as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). In the project survey area, mule deer were observed as individuals or in small herds in ponderosa pine and cottonwood riparian habitats along Beaver and Pass Creeks, and in the pine breaks along the eastern edge of the PAA. They are considered year-round residents in the survey area.

By nature, elk are shy animals that are less accepting of human disturbance than pronghorn (Fitzgerald et al. 1994) or deer. Elk in the project survey area share their range with pronghorn and domestic cattle from spring through fall. Because elk prefer grass to shrubs, the resident herd competes more directly with domestic cattle and wild horses than with pronghorn in the spring and summer months. A herd of six bull elk was observed in the survey area in ponderosa pine habitat on one occasion (June 2008) during the baseline survey period, but local residents report that elk are frequently seen in the pine stands, especially during fall and winter.

White-tailed deer are typically associated with forests, woodlands, and treed galleries along streams (Fitzgerald et al. 1994). Small numbers of white-tailed deer were observed in the project survey area during the baseline survey period, predominantly in the cottonwood corridor along Pass Creek in the central portion of the PAA. Most sightings of white-tailed deer were actually in the cottonwood corridor along the Cheyenne River, approximately 2-2.5 miles south of the PAA. This species is considered an uncommon year-round resident in the survey area itself.

2.8.5.4.3 Other Mammals

A variety of small and medium-sized mammalian species have the potential to occur in the project survey area, although not all were observed in the PAA itself during the baseline wildlife surveys. These potential species include a variety of predators and furbearers such as the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), badger (*Taxidea taxus*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*).

Numerous prey species, including rodents (e.g., mice, rats, voles, gophers, ground squirrels, chipmunks, prairie dogs, etc.), jackrabbits (*Lepus* spp.), and cottontails (*Sylvilagus* spp.) can also be found in the project survey area. These species are cyclically common and widespread throughout the region, and are important food sources for raptors and other predators. Each of these prey species, with the exception of chipmunks and rats, were either directly observed during the field surveys, or were known to exist through burrow formation or scat. Jackrabbit sightings were uncommon and cottontail sightings were below normal, suggesting these species are currently in a local downward trend. Observations of small mammals occurred most often near Beaver and Pass Creeks, in the northwestern and central portions of the survey area, respectively.

One black-tailed prairie dog (*Cynomys ludovicianus*) colony is located in the northwestern corner of the PAA, and two others are present in the southwestern portion of the one-mile perimeter.

Local ranchers use shooting and other control methods to reduce and/or eradicate prairie dogs from the PAA (private surface) and surrounding private lands.

Other mammal species such as the striped skunk (*Mephitis mephitis*), porcupine (*Erethizon dorsatum*), and various weasels (*Mustela* spp.) inhabit sage-steppe communities, but no sightings or confirmed scat were recorded for these species during the surveys. Infrequent, incidental bat sightings (species unknown) occurred during nocturnal amphibian surveys and spotlighting efforts at targeted ponds in the PAA during the baseline period. A northern river otter (*Lontra canadensis*) carcass was unexpectedly discovered at one of the fisheries sampling points along Beaver Creek in April 2008. The otter may have come up the creek during the flooding that occurred in early April, though the cause of death was not apparent. The carcass was gone by the July sampling period, presumably washed back downstream with the next flood event. Otters are tracked by the SDNHP.

Small mammal trapping was conducted during fall 2007 as part of the baseline survey requirements for the project. Trapping occurred in nine transects spread among six habitat types: Upland Grassland, Ponderosa Pine, Greasewood, Cottonwood Gallery, Clay Breaks, and Pine/Sage Edge. Grassland habitats occupy the largest parcels throughout the area, and held four transects; the remaining habitats held one transect each. Each transect included a combination of 20 live traps, 10 snap traps, and 5 pitfall traps. All traps were baited daily, with cotton balls placed in the live and pitfall traps for nesting material. Each transect was run for three consecutive days and nights (per SDGFP). The deer mouse (*Peromyscus maniculatus*) dominated the captures, with only seven individuals of other species recorded (Table 2.8-19). Deer mice are known for their ubiquitous presence and generalized habitat use, and these survey results are similar to those from other recent trapping efforts in northwest South Dakota.

Table 2.8-19 Small Mammal Abundance[1] during Trapping within the Proposed Action Area in September 2007

Species	Total
Deer mouse (*Peromyscus maniculatus*)	152
Olive-backed pocket mouse (*Perognathus fasciatus*)	3
Western harvest mouse (*Reithrodontomys megalotis*)	3
Northern grasshopper mouse (*Onychomys leucogaster*)	1
Totals	**159**

Lagomorph (hares and rabbits) surveys are also a common component of baseline wildlife inventories. Spotlight lagomorph counts were conducted on two consecutive nights in fall 2007. Cottontail abundance was twice that of jackrabbits, though neither count was especially high (Table 2.8-20). Results from lagomorph surveys conducted in northeast Wyoming annually since 1984 indicate that the regional lagomorph population is experiencing a downward trend in its regular cyclic pattern. Although no data is available from the PAA prior to 2007, its proximity to the annual survey area in Wyoming suggests that the population trend is similar in southwestern South Dakota.

Table 2.8-20: Total Lagomorphs Observed During Spotlight Surveys and Abundance Indices within the Proposed Action Area in September 2007

	Species		
	White-tailed jackrabbit	**Cottontail**	**Totals**
Total Count	**12**	**28**	**40**
Lagomorphs/Survey Mile	**1.5**	**3.4**	**4.9**

[1] Survey route totaled 8.2 miles.
[2] Number given is highest count per species from two survey nights.

2.8.5.4.4 Raptors

Raptor species observed during the project baseline wildlife surveys included the bald eagle, red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), turkey vulture

(*Cathartes aura*), Cooper's hawk (*Accipiter cooperii*), rough-legged hawk (*Buteo lagopus*), merlin (*Falco columbarius*), great horned owl (*Bubo virginianus*), and long-eared owl (*Asio otus*). Other raptor species could also occur in the survey area, particularly as seasonal migrants, but were not seen during the 2007 and 2008 inventories.

Raptor sightings were recorded frequently throughout the project survey area during 2007 and 2008 in ponderosa pine, cottonwood riparian, and grassland habitats. Observations were most concentrated in proximity to Beaver Creek and Pass Creek, perhaps because of prey availability due to the presence of water and better vegetative cover along those drainages. Raptors were observed hunting, perching on nest trees, power poles, and topographic features, nest tending, incubating, and exhibiting nest defense. The bald eagle, red-tailed hawk, American kestrel, and northern harrier were the most commonly seen raptor species in the area. Raptor sightings for those species were recorded with regularity during all four seasons during the baseline survey period, though some of those species may leave the area under harsher winter conditions.

Biologists watched for active raptor nests and breeding behavior (territory defense, courtship flights, prey deliveries, etc.) during all site visits within the breeding season. Additional nest searches were conducted concurrent with other surveys completed during the non-breeding season. Nests were monitored from a distance using binoculars and a spotting scope early in the nesting season to avoid impacting active nests. All active nests were monitored throughout the breeding season to determine their success and production level.

Five confirmed, intact (i.e., material present) raptor nests and one potential nest site were documented in the PAA during the 2007-2008 baseline survey period; two additional nests were recorded in the one-mile survey perimeter (see Plate 2.8-3). All eight nests are listed in Table 2.8-21, including their locations, and their status and productivity in 2008. Three raptor species tracked by the SDNHP nested in the PAA. The bald eagle and long-eared owl (*Asio otus*) successfully nested within the PAA. A merlin (*Falco columbarius*) was recorded at a potential nest site in the pine breaks east of the proposed project boundary. The bird exhibited defensive behavior near the nest site, but no young or signs of active use (e.g., droppings, prey remains, egg shells, etc.) were recorded there.

Table 2.8-21: Raptor Nest Locations and Activity in and Within1 Mile of the Proposed Action Area during Baseline Wildlife Surveys from mid-July 2007 through early August 2008

Species[1,2]	¼ Section	Township/Range	Habitat	Status	Location
LEOW	**SESW 35**	**6 South/1 East**	**Ponderosa Pine**	**1+ owl fledged**	**Permit area**
RTHA (2 nests)	SENE 29	6 South/1 East	Ponderosa Pine	1 hawk fledged	Permit area
RTHA	SESW34	6 South/1 East	Cottonwood-riparian	2 hawks fledged	Permit area
BAEA	**Mid-SW 30**	**6 South/1 East**	**Cottonwood-riparian**	**1 eagle fledged**	**Permit area**
MERL	**NWSW 36**	**6 South/1 East**	**Ponderosa Pine**	**Nest defense but no confirmed young**	**1-mile perimeter**
GHOW	SWNE 5	7 South/1 East	Lone, live cottonwood tree	Status unknown[3]	Permit area
Unk Buteo	NWSE 27	41 North/60 West (Wyoming)	Lone, dead cottonwood tree	Inactive	1-mile perimeter

[1] **Bold** species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).
[2] Species Codes:
BAEA = Bald eagle
GHOW = Great horned owl
LEOW = Long-eared owl
MERL = Merlin
RTHA = Red-tailed hawk
Unk Buteo = Unknown *Buteo* (soaring hawks) species
[3] One adult GHOW was observed in the nest tree, but no chicks, feathers, droppings, or prey items were observed in or on the nest, or on the ground under the nest.

2.8.5.4.5 Upland Game Birds

The wild turkey (*Meleagris gallopavo*) and mourning dove (*Zenaida macroura*) were the only upland game bird species observed in the project survey area during baseline inventories conducted from July 2007 to August 2008. Both species are relatively common and occur in a variety of woodland and open habitats in the PAA.

Three grouse species could potentially occur in the PAA (PAA and one-mile perimeter): the greater sage-grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and ruffed grouse (*Bonasa umbellus*). The greater sage-grouse is a species of great concern throughout the west, and is considered a "landscape species" due to its use of wide expanses of sagebrush as primary habitat during each phase of its life cycle. Searches for grouse leks were completed between April 7 and May 12, 2008. Surveys were conducted between first light and approximately one hour after sunrise. Biologists searched for displaying grouse by driving through the PAA and one-mile perimeter, and making frequent stops at vantage points to scan and listen for strutting birds. Although sage-grouse were historically recorded in the general vicinity (TVA DES 1979), no leks have been documented by agency biologists within 6 miles of the PAA in recent years. No grouse were observed during the entire year-long baseline survey period for this project. Potential habitat for sage-grouse is present, but only in small stands of sage surrounded by grasslands and pine breaks; such habitat is not conducive to supporting a population of sage-grouse.

2.8.5.4.6 Other Birds

Lists of avian species tracked by the SDNHP were obtained from Mr. S. Michals (SDGFP) in July 2007 and the SDGFP website in September 2008. Biologists watched for all vertebrate species of concern during each site visit to the PAA during the year-long baseline survey period. All observations were recorded, including notes on species, number of individuals, age and sex (when possible), location, habitat, and activity. Three species of special interest (i.e., tracked by the SDNHP) were observed while conducting other surveys during the baseline inventory period: the Cooper's hawk (*Accipiter cooperii*), golden eagle (*Aquila chrysaetos*), and Clark's nutcracker (*Nucifraga columbiana*). All three species were briefly observed flying over the PAA, but no known nesting or other targeted use was recorded by these species.

In addition to those incidental observations, targeted surveys for breeding birds (primarily passerines) were conducted in the same habitats and along the same general transects within the PAA as the small mammal trapping. Four transects were surveyed in Upland Grassland, and one each in the remaining five habitat types. Breeding bird surveys were conducted using belt transects measuring 100 m wide by 1,000 m long. Transects were surveyed by slowly walking through the center of each line and stopping at least every 50 m to watch and listen for birds. Individuals observed while walking were also recorded, with efforts made to avoid double counting birds. Each transect was surveyed on three consecutive mornings in June 2008. To reduce bias, surveys started in a different habitat type each morning. Surveys began between dawn and sunrise, and were completed within four hours. All birds were identified to species. Flyovers and birds seen and heard beyond the transect boundaries were recorded as incidentals, but were not included in the analysis. Surveys were not conducted during inclement weather (precipitation, moderate to heavy winds, etc.).

Weather conditions during all surveys were mostly calm and clear, with a light breeze and approximately 25 percent high, thin cloud cover. Thirty-six species were observed within the breeding bird transects during spring 2008, with two additional unknown species logged (Table 2.8-22). The western meadowlark (*Sturnella neglecta*) was the most common species, followed by the mourning dove. The dove was the only species recorded in all six habitat types. The long-billed curlew (*Numenius americanus*) was the only species of the 36 observed that is tracked by the SDNHP. As expected, several species were associated with specific habitat types. For example, the curlew was only seen in the grassland transects (Table 2.8-22). Likewise, several species typically associated with trees were only observed in or immediately adjacent to the Cottonwood Gallery or Ponderosa Pine transects: the chipping sparrow (*Spizella passerina*), mountain bluebird (*Sialia currucoides*), black-capped chickadee (*Poecile atricapillus*), and yellow-rumped warbler (*Dendroica coronata*), among others. Similar associations were noted between other species and habitats.

Table 2.8-22: Breeding Bird Species Richness and Relative Abundance in Six Habitat Types within the Proposed Action Area in June 2008

	Average Number of Birds per Habitat Type[1]						
Species[2]	BB	COT GAL	G	GW	P-SB Edge	PP	AVG #/PLOT
Western meadowlark (*Sturnella neglecta*)	3.0	1.7	2.9	7.0	2.0	---	2.8
Mourning dove (*Zenaida macroura*)	5.0	1.7	1.9	0.7	0.3	2.0	1.9
Long-billed curlew (*Numenius americanus*)	---	---	1.9	---	---	---	0.9
Chipping sparrow (*Spizella passerina*)	---	---	---	0.3	4.0	1.6	0.6
Lark sparrow (*Chondestes grammacus*)	3.7	---	---	---	1.7	---	0.6
Grasshopper sparrow (*Ammodramus savannarum*)	---	---	0.1	4.3	---	---	0.5
Northern flicker (*Colaptes auratus*)	---	4.3	---	0.3	---	---	0.5
Mountain bluebird (*Sialia currucoides*)	---	---	---	---	2.3	2.0	0.5
Brewer's blackbird (*Euphagus cyanocephalus*)	---	3.7	---	---	---	---	0.4
Spotted towhee (*Pipilo maculatus*)	---	1.3	---	0.3	0.7	1.0	0.4
American kestrel (*Falco sparverius*)	0.3	2.3	0.2	---	---	---	0.4
Brown-headed cowbird (*Molothrus ater*)	---	0.3	---	---	2.0	1.0	0.4
House wren (*Troglodytes aedon*)	---	2.7	---	---	---	---	0.3
Yellow warbler (*Dendroica petechia*)	---	2.0	---	---	---	---	0.2
Say's phoebe (*Sayornis saya*)	---	0.3	---	---	1.3	---	0.2
Bullock's oriole (*Icterus bullockii*)	---	1.7	---	---	---	---	0.2
Unknown flycatcher	---	---	---	---	---	1.7	0.2
Eastern kingbird (*Tyrannus tyrannus*)	---	1.3	---	---	---	---	0.1
Red-tailed hawk (*Buteo jamaicensis*)	---	0.3	0.1	0.3	---	---	0.1
Black-capped chickadee (*Poecile atricapillus*)	---	0.3	---	---	---	0.7	0.1
Yellow-rumped warbler (*Dendroica coronata*)	---	0.3	---	---	---	0.7	0.1

Table 2.8-22: Breeding Bird Species Richness and Relative Abundance in Six Habitat Types within the Proposed Action Area in June 2008 (Concl.)

	Average Number of Birds per Habitat Type[1]						
Species[2]	BB	COT GAL	G	GW	P-SB Edge	PP	AVG #/PLOT
European starling (*Sturnus vulgaris*)	---	1.0	---	---	---	---	0.1
Great horned owl (*Bubo virginianus*)	---	1.0	---	---	---	---	0.1
Vesper sparrow (*Pooecetes gramineus*)	---	---	0.3	---	---	---	0.1
American crow (*Corvus brachyrhynchos*)	---	---	0.1	---	---	0.3	0.1
Red-headed woodpecker (*Melanerpes erythrocephalus*)	---	0.7	---	---	---	---	0.1
Rock wren (*Salpinctes obsoletus*)	0.7	---	---	---	---	---	0.1
Western kingbird (*Tyrannus verticalis*)	I	0.7	---	---	---	---	0.1
American robin (*Turdus migratorius*)	---	0.3	---	---	---	---	<0.1
Common nighthawk (*Chordeiles minor*)	---	I	---	---	---	0.3	<0.1
Indigo bunting (*Passerina cyanea*)	---	0.3	---	---	---	---	<0.1
Killdeer (*Charadrius vociferous*)	---	---	0.1	---	---	---	<0.1
Lazuli bunting (*Passerina amoena*)	---	0.3	---	---	---	---	<0.1
Western wood peewee (*Contopus sordidulus*)	---	---	---	---	0.3	---	<0.1
Yellow-breasted chat (*Icteria virens*)	---	0.3	---	---	---	---	<0.1
Red-winged blackbird (*Agelaius phoeniceus*)	---	---	I	---	---	---	I
Turkey vulture (*Carthartes aura*)	I	I	---	---	---	---	I
Average # Birds/Transect	12.3	29.0	7.7	13.3	15.3	10.7	12.4
TOTAL SPECIES	5	23	10	7	10	10	36

BB = Bentonite breaks
COT GAL = Cottonwood Gallery
G = Grassland
GW = Greasewood
P-SB = Pine-sagebrush
PP = Ponderosa pine
I = Incidental flyover during breeding bird survey (not counted in totals)

[2] **Bold** species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

2.8.5.4.7 Waterfowl, Shorebirds

Under natural conditions, the PAA provides limited seasonal habitat for waterfowl and shorebirds. As described previously, natural aquatic habitats in the PAA occur mainly in Beaver Creek and Pass Creek, with a few scattered stock reservoirs also present. Because of the limited precipitation in the area, such habitats are available primarily during the spring migration period, with less reliable nesting and brood-rearing habitat in the area.

Although specific surveys for waterfowl and shorebirds were not required for the project, biologists recorded all birds seen during the year-long survey period. Eight species associated specifically with water and/or wetlands were observed during the baseline inventories: the American white pelican (*Pelecanus erythrorhynchos*), great blue heron (*Ardea herodias*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), American wigeon (*Anas americana*), killdeer (*Charadrius vociferus*), long-billed curlew, and upland sandpiper (*Bartramia longicauda*). The pelican, heron, and curlew are tracked by the SDNHP.

2.8.5.4.8 Reptiles and Amphibians

The aquatic resources present within the PAA and surrounding perimeter have been thoroughly described in the General Setting and Waterfowl and Shorebird sections, above. Water is a limiting factor throughout the survey area and surrounding lands, with only one perennial stream passing through the western extent of the PAA and all other natural flow categorized as intermittent or ephemeral. Even the perennial Beaver Creek experiences extended periods of low volume and flow in most years. The creeks are meandering streams with extended reaches of muddy soil substrates and intermittent riparian vegetation. Aquatic species are not locally common inhabitants of the PAA. The lack of deep-water habitat and multiple perennial water sources limits the presence of fish, and decreases the potential for other aquatic species to exist.

Three aquatic or semi-aquatic amphibian species and one aquatic reptile were recorded during the 2007 and 2008 surveys in the PAA: the boreal chorus frog (*Pseudacris triseriata*), Woodhouse's toad (*Bufo woodhousei*), great plains toad (*B. cognatus*), and western painted turtle (*Chrysemys picta*). All four species were heard and/or seen in Beaver Creek as it flows through the western portion of the PAA, or near stock reservoirs. All four species are common to the PAA, and the region as a whole. One additional aquatic reptile was recorded in the perimeter surrounding the PAA, the western spiny softshell (*Trionyx spiniferus*). That observation also occurred in Beaver Creek, during the July 2008 fisheries sampling session.

Lizards (species unknown) were often observed sunning themselves on rocks and on sandy soil in the summer months during all except the early morning hours. These sightings were widespread throughout the survey area, with observations increasing as the summer progressed and the days got hotter. The shed remains of a snake skin were found in the north central portion of the survey perimeter in early May, 2007. The skin was at the base of a rock outcrop and looked as though it may have belonged to a bullsnake (*Pituophis cantenifer*).

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

2.8.5.5.1 Federally Listed Species

No federally listed vertebrate species were documented in the project survey area (current PAA and one-mile perimeter) during the year-long survey period. The black-footed ferret was the only federal T&E vertebrate species that could potentially occur in the PAA. The U.S. Fish and Wildlife Service issued a block-clearance for ferrets throughout the entire state of South Dakota in recent years, including the project survey area in extreme southwestern Custer County and northwestern Fall River County. The only exception to that clearance is in Custer State Park in northern Custer County. Although surveys were not required for the project, they were conducted in the general vicinity of the PAA during monitoring performed for the TVA DES in fall 1977 (TVA DES 1979). No ferrets or evidence of their presence (e.g., trenching, tracks, or scat) were observed during those historic surveys, or during the recent survey period.

2.8.5.5.2 State Listed Species

The State of South Dakota lists 23 vertebrate species as threatened or endangered:

- Threatened: 4 fish, 4 birds, 2 mammals, 1 snake, and 1 turtle
- Endangered: 5 fish, 4 birds, 1 mammal, and 1 snake

The current list of these state species is available on the SDGFP website: http://www.sdgfp.info/Wildlife/Diversity/TES.htm.

Only 1 of those 23 state-level T&E species was documented within the PAA or one-mile perimeter during the survey period (mid-July 2007 through early August 2008). Although the bald eagle was removed from the federal listing process in August 2007, it is still considered as a threatened species at the state level in South Dakota. Bald eagles were repeatedly observed along Beaver Creek in the western portion of the proposed permit area and perimeter during winter roost surveys conducted in late 2007 and early 2008. One active bald eagle nest is located in the northwestern portion of the revised permit area in mid-SW¼ Section 30, Township 6 South, Range 1 East. The nest is in a cottonwood tree along Beaver Creek. The nest fledged one young in 2008.

2.8.5.5.3 Species Tracked by SDNHP

As described in previous sections, current lists of other vertebrate species of interest or concern tracked by the SDNHP were obtained from SDGFP through personal contacts (July 2007) and from the agency's website (September 2008).

Six vertebrate sensitive species or species of local concern other than the bald eagle were documented within the current (September 2008 configuration) PAA during the baseline survey period: the long-billed curlew, great blue heron, golden eagle, Cooper's hawk, American white pelican, and long-eared owl. The long-eared owl and curlew are known or are suspected to have nested in the permit area, based on evidence (young present) or persistent defensive behavior, respectively. The heron, golden eagle, Cooper's hawk, and pelican were merely observed flying over the area; those four species were recorded only once each.

These six species of special interest are considered as secure populations within their respective overall ranges, though one or more could be less common in parts of a given range, especially in the periphery. Likewise, all six are considered to be either rare and local throughout their statewide ranges, or locally abundant in restricted portions of those ranges.

Four additional vertebrate species of concern were documented at least once each in the one-mile perimeter: the northern river otter, merlin, Clark's nutcracker, and plains topminnow (*Fundulus sciadicus*). The otter and birds were described in preceding sections of this document. The topminnow was captured during fisheries sampling efforts in Beaver Creek, beyond all permit boundary outlines, in July 2008. Additional information about those survey efforts and results is presented in Section 2.8.5.5 (Aquatic Resources), below.

2.8.5.6 Aquatic Resources

2.8.5.6.1 Aquatic Species and Habitats

2.8.5.6.1.1 Aquatic Species and Habitats-Survey Methods

Because Beaver Creek is the only perennial stream in the PAA, and is the receiving water for drainage from the portions of the PAA identified for proposed future ISL activities, it was the focus of aquatic habitat monitoring efforts conducted for this project. Some sampling was also conducted in the Cheyenne River downstream of the PAA to obtain additional site data. Beaver Creek is listed as impaired under Section 303(d) of the federal Clean Water Act for the following constituents: oil, specific conductivity, temperature, total dissolved solids, and total suspended solids (EPA 2008).

Baseline monitoring stations were located at sites that were previously established as water quality monitoring locations on Beaver Creek and the Cheyenne River. Using these sites allows a comparison with past and ongoing water quality records. One site (BVC04) is located upstream and the other (BVC01) is downstream of the proposed ISL activities (refer to Plate 2.5-1 for site locations). Fish sampling for species, abundance, and radiological testing was conducted at both Beaver Creek sites, and at a site on the Cheyenne River downstream of the Beaver Creek confluence (site CHR05).

Baseline sampling of aquatic habitat, benthic macro-invertebrates, and fish was conducted according to protocols developed by the South Dakota Department of Environment and Natural Resources (SDDENR 2002) and the SDPFG (S. Michals, personal communication 2008). Aquatic data collected at the two Beaver Creek sites during the baseline sampling included: stream habitat description; aquatic benthic macro-invertebrate community composition; the variety, condition, and relative abundance of fish species; and radiological analysis of fish collected. As indicated, fish sampling also occurred at CHR05, though SDGFP did not require the other aquatic sampling efforts to be conducted at that location.

Habitat, invertebrate, and fish sampling was conducted during spring (April) and summer (July) conditions in 2008 to provide a baseline for semi-annual monitoring described in NRC Guide 4.14 (NRC 1990). This timing was selected to capture seasonal differences, including high and base flow conditions. However, the late spring and early summer of 2008 were unusually wet and, as a result, the flow during both seasonal events was similar. Consequently, neither sampling effort represented the low summer flow conditions that have typically occurred at these sites in recent years (M. Hollenbeck, personal communication 2008).

The habitat description and invertebrate collection efforts followed the SDDENR protocol (SDDENR 2002). Eleven cross-section transects were established at equidistant intervals from the downstream end of each sample site. The longitudinal distance of each survey reach was established as the distance equal to 30 average channel widths as determined by 10 preliminary width measurements.

Fish sampling was accomplished by blocking and seining a 100-meter survey reach downstream of each sample site, according to SDPFG guidelines (S. Michals, personal communication 2008). Due to obstacles in the stream, it was not feasible to seine an entire reach in one sweep, so three separate sweeps were made at a given sample site and fish were collected on shore at three locations within each 100-meter reach. All fish captured were identified, counted, measured, and weighed. Individuals that were less than 100 millimeters (mm) in length were combined for a composite weight by species.

Numerous fish were collected for radiological testing during each of the spring and summer flow sampling events. The initial target at each sample site was six individual fish, preferably from six different species (i.e., 6 fish per sample site, 18 total fish), though fewer fish were retained if the target was not achieved. Many of the specimens collected in April 2008 contained no detectable uranium. In an effort to improve the protocol to better represent conditions in sampled fish populations, up to five individuals of each of six species (i.e., 30 fish per sample site, 90 total fish) were collected in July (when available in the catch) and processed for radiology.

Live fish were bagged, frozen, and kept frozen until they were analyzed for the following:

- Uranium (mg/kg)
- Uranium (μCi/kg)
- Thorium-230 (μCi/kg)
- Radium-226 (μCi/kg)
- Lead-210 (μCi/kg)
- Polonium-210 (μCi/kg)

These analytes are specified in NRC Guide 4.14. Analysis was conducted by Energy Laboratories Inc., in Casper, Wyoming. Lab results are included in Appendix 2.8-H, and are summarized in Table 2.8-23.

Table 2.8-23: Beaver Creek Baseline Radiological Analysis of Whole Fish

Site	Species	No.	Length[a] mm	Sample Weight [b] g	U mg/kg	U uCi/Kg	Po 210 uCi/Kg	Pb 210 uCi/Kg	Th 230 uCi/Kg	Ra 226 uCi/Kg
BVC01 – April	GRS	1	120	22.96	ND	ND	u	u	u	0.0003
	PLK	1	48	1.77	ND	ND	u	0.02[c]	0.0002	u
	LND	1	48	0.64	ND	ND	0.002	u	0.0001	u
	FHM	1	30-60	4	ND	ND	0.0004	u	u	u
BVC04-April	PLK	1	40-60	0.72	ND	ND	u	u	u	u
	RIC	1	111	18.79	ND	ND	0.0004	u	0.00002	u
	GRS	1	50	2.16	ND	ND	0.0006	u	0.0008	u
	FHM	1	30-70	~1.2	ND	ND	u	u	0.00001	0.0004
	CHC	1	215	72	0.05	30	0.0009	u	0.00002	u
CHR05-April	RIC	1	97	13.73	ND	ND	0.0008	u	u	u
	GRS	1	98	13.67	ND	ND	0.00008	u	0.00001	u
	SRS	1	169	55.05	ND	ND	0.0002	u	0.00002	u
	CRC	1	30-70	2.92	ND	ND	u	u	u	u
	PLK	1	32-74	1.51	ND	ND	u	u	0.0001	u
	SAS	1	30-60	1.51	ND	ND	u	u	0.001	u
BVC01-July	FHM	5	42-67	~8	0.026	0.000018	0.0004	u	u	u
	CAP	1	171	73	0.0098	0.0000067	0.00078	u	u	u
	SAS	5	46-62	7	0.031	0.000021	0.00023	u	0.000098	u
	PLK	5	57-71	9	0.035	0.000024	0.00047	u	u	u
	PLT	5	48-71	12	0.021	0.000014	0.00035	u	0.0001	u
BVC04-July	SAS	5	45-58	~6.7	0.024	0.000016	0.00054	u	0.000027	u
	FHM	5	42-61	~3.7	0.031	0.000021	0.00018	u	u	u
	CAP	1	260	237	0.014	0.0000094	0.00015	u	0.0000023	u
	PLK	5	48-68	~7.2	0.019	0.000013	u	u	0.000094	u

Table 2.8-23: Beaver Creek Baseline Radiological Analysis of Whole Fish

Site	Species	No.	Length[a] mm	Sample Weight[b] g	U mg/kg	U uCi/Kg	Po 210 uCi/Kg	Pb 210 uCi/Kg	Th 230 uCi/Kg	Ra 226 uCi/Kg
	SRS	1	136	130	0.0072	0.0000049	0.00017	u	u	u
CHR05-July	FHM	5	38-60	~0.7	0.024	0.000016	0.00042	u	u	u
	SAS	5	42-60	~1.5	0.04	0.000027	0.00049	u	0.00014	u
	CAP	1	135	31	0.01	0.0000069	0.00074	u	0.000017	u
	RIC	4	381-415	5150	0.031	0.000021	u	u	u	0.000008
	SRS	2	146-160	78	0.0066	0.0000044	0.00005	u	0.0000032	u
	PLK	4	46-68	~7.4	0.017	0.000012	0.00047	u	u	u
	CHC	3	181-290	265	0.017	0.000012	0.00016	u	0.000009	u

2.8.5.6.1.2 Aquatic Species and Habitat-Survey Results

2.8.5.6.1.2.1 Habitat

Compiled habitat data forms may be found in Appendix 2.8-I. Summaries of results by site are described below.

Site BVC04

Site BVC04 is located downstream of the Old Highway 85 bridge over Beaver Creek in Weston County, WY (refer to Plate 2.5-1 for site locations). This site was selected as the background site as it is upstream of all proposed project. At BVC04, Beaver Creek is a low gradient prairie stream that is deeply incised in places, is subject to large fluctuations in flow, and shows significant evidence of active erosion (bank slumping, bare soil) and sediment deposition on stream banks and in slow moving pools.

<u>April</u>
The preliminary average channel width at BVC04 was 7.35 meters. Sample transects were located 18.5 meters apart, with a total surveyed reach length of 185 meters. During the April

habitat survey, water temperature varied from 7.0° C to 16.0° C, indicating that stream temperature is highly variable during the day. In general, riparian vegetation is limited to herbaceous and short shrubs, with only occasional trees. With the exception of the bridge, there was no shade present in the center of the channel. As a result, the creek is subject to substantial solar heating during the day. Water was clear during the survey, although specific conductivity was high (5,109 μS/cm), indicating a high concentration of dissolved solids typical of prairie streams in this region. Discharge at BVC04 was 7.31 cfs on April 14.

Within the BVC04 survey reach, habitat included two large pools, two glides, and 3 riffles. The total length of riffles was 54.6 m.

Beaver Creek carries a heavy sediment load during high flow, resulting in a deep layer (up to 2 feet) of fine silt deposited in pools. Silt dominates the sediment composition of the reach, although sand, gravel and cobbles dominate the substrate of the faster moving riffle and glide areas. The cumulative and proportional particle distribution of sediment in the BVC04 reach during the April survey is shown in Figure 2.8-4. This distribution indicates a predominance of silt and sand, with gravel in the riffle areas. Large wood in the reach was located in riffle and glide areas and was generally comprised of small (0.1 to 0.25 m diameter) pieces in the portion of the channel between the wetted channel and the bank full elevation.

Beaver Creek is significantly incised. Bank slumpage was observed at eight transects and erosion at ten of the eleven transects in this reach. The wetted stream width during the survey was 4.2 to 10.7 meters; bank-full width ranged from 5.3 to 11.3 meters; and the width at the top of bank was 10.7 to 17.1 meters. Bank height was up to 2.0 meters. Riparian land use is rangeland with no riparian buffer, cattle have access to the stream, especially in the vicinity of the bridge. Woody vegetation has probably been sparse along Beaver Creek stream banks for many years, which may have contributed to channel down-cutting and erosion, and a general lack of large woody debris and cover in the channel. Examples of channel dimensions in pool, riffle, and run habitat types of the upstream (BVC04) site are shown in Figures 2.8-5, 2.8-6, and 2.8-7, below.

As mentioned previously, pools contained a large volume of silt. This silt reduces the depth and volume of the pools, reducing the quality and quantity of available fish habitat. Due to pool filling and lack of cover, pool quality is poor.

Powertech (USA) Inc.

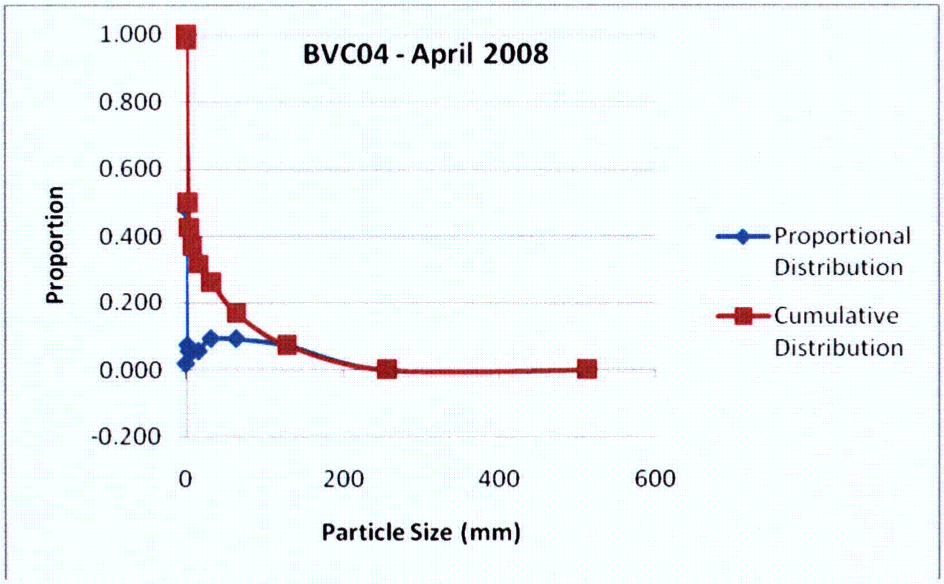


Figure 2.8-4: Cumulative and Proportional Sediment Particle Distribution at Site BVC04, Transects 1 through 11 Combined, April 2008

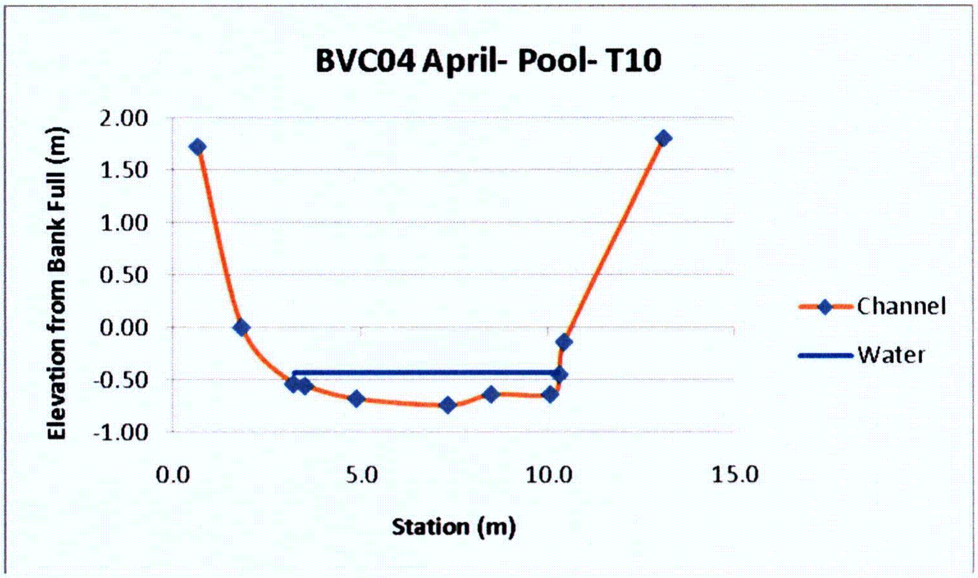


Figure 2.8-5: Channel Dimensions in Pool Habitat, Transect 10

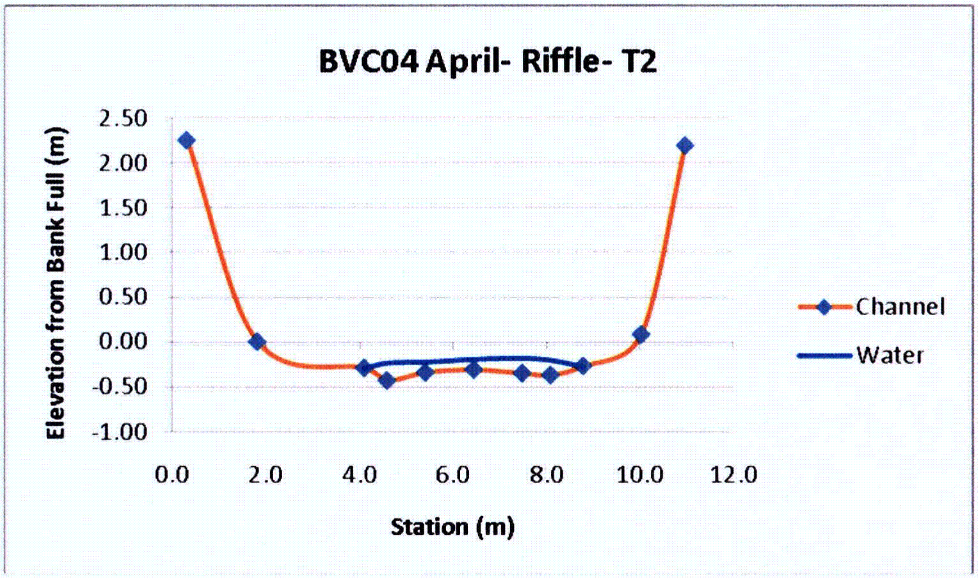


Figure 2.8-6: Channel Dimensions in Riffle Habitat, Transect 2

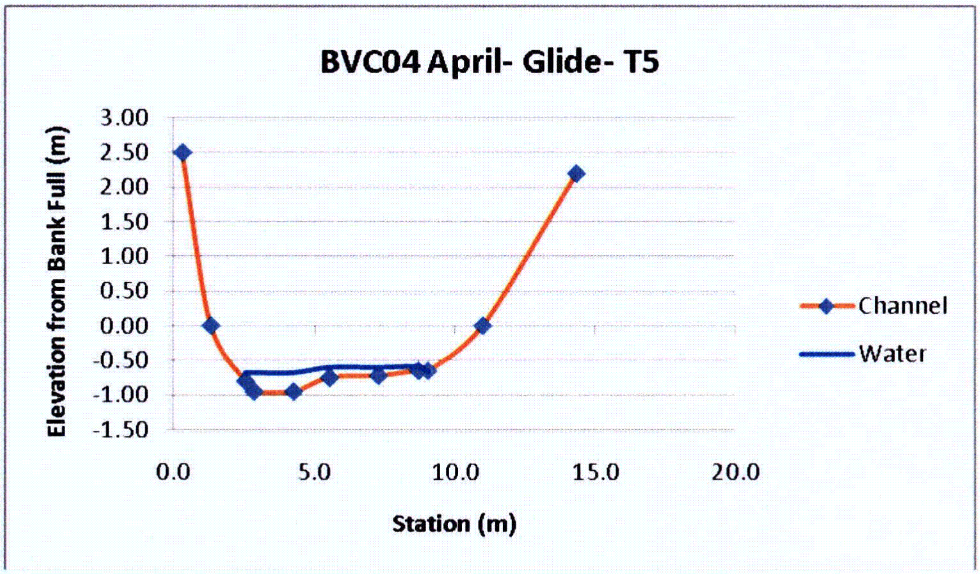


Figure 2.8-7: Channel Dimensions in Glide Habitat, Transect 5

July

In July 2008, the channel dimensions were essentially the same as measured during April, with some localized changes. Between the April and July field visits Beaver Creek experienced high flows that appeared to have resulted in somewhat less fine sediment in the pools, and transport of woody debris out of the survey reach. Stream discharge in July was 12.3 cfs, approximately 5 cfs higher than in April. The average wetted width measured was 6.9 meters in April and 7.5 meters in July.

The July air temperature reached 25° to 35° C and water temperatures were quite warm at 23° C to 24° C. As during April, riparian vegetation was limited to herbaceous and short shrubs, with only occasional trees. Shade along the banks was greater in July, since trees were generally bare in April and fully leafed-out in July. However, most of the stream channel itself was unshaded during both site visits indicating a high degree of solar warming is typical in Beaver Creek.

Within the BVC04 survey reach, habitat included 1 pool, 3 glides, and 3 riffles. The total length of riffles was 59.9, although two riffle segments ran to either side of an island. If these two are considered together, the riffle length measured 43.9 m.

As described under spring conditions, fine silt dominated the sediment composition of the reach and filled the larger part of the pools in at this site. Sand, gravel and cobbles dominate the substrate of the faster moving riffle and glides. The cumulative and proportional particle distribution of sediment for the BVC04 reach during the summer survey is shown in Figure 2.8-8 demonstrating a slightly higher proportion of gravel in the overall substrate composition than in April.

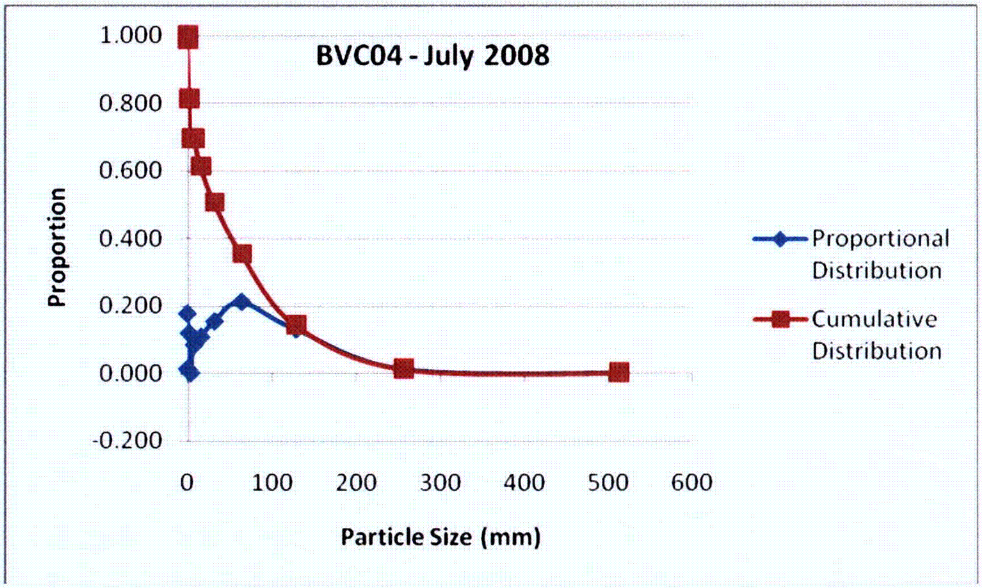


Figure 2.8-8: Cumulative Sediment Particle Distribution at Site BVC04, Transects 1 through 11 Combined during July

Large wood in the reach was essentially absent in July. Small pieces that had been present in April apparently were washed out of the survey reach during the peak flows that occurred in June.

The wetted stream width during the summer survey was 4.3 to 10.1 meters; bank-full width ranged from 6.0 to 11.2 meters; and the width at the top of bank was 15.0 to 21.0 meters. Bank height was 2.1 to 3.9 meters.

As mentioned previously, pools contained a large volume of silt. This silt reduces the depth and volume of the pools, reducing the quality and quantity of available fish habitat. Due to pool filling and lack of cover, pool quality is poor.

Site BVC01

Site BVC01 is located upstream of the Argentine Road bridge over Beaver Creek in Fall County, SD. This site was selected as the test site as it is downstream of most proposed operations and all proposed land application sites.

At BVC01, Beaver Creek is still a low gradient, incised prairie stream as it is at BVC04. However, the stream gradient is slightly higher and banks are generally lower. Riparian habitat along BVC01 is more actively managed for cattle grazing than BVC04 and there are fewer trees and shrubs and more grass at BVC01 than at BVC04. Fine sediment was present in pools. However, there appeared to be less fine sediment in July indicating that high flows transported sediment out of this reach.

<u>April</u>

The preliminary average channel width at BVC01 was 7.35 meters. Sample transects were located 22 meters apart, with a total surveyed reach length of 220 meters.

During the April habitat and fish surveys, water temperature varied from 11.8° C to 16.9° C, indicating that stream temperature at this site is also variable during the day. As was the case at site BVC04, riparian vegetation at BVC01 was limited to herbaceous and short shrubs, with only a single boxelder tree in the survey reach. With the exception of the bridge, there was no shade present in the center of the channel and the creek is subject to substantial solar heating during the day.

Water was clear during the survey, although specific conductivity was high (7,186 μS/cm); somewhat higher than observed at BVC04. Discharge at BVC01 was 5.08 cfs on April 14, 2008.

Within the BVC01 survey reach, habitat included 3 pools, 2 glides, and 3 riffles. The total length of riffles was 28 meters.

Overall, gravel dominated the sediment composition of the BVC01 reach. The cumulative and proportional particle distribution of sediment for the BVC01 reach during the April survey is shown in Figure 2.8-9. This distribution indicates a predominance of gravel with some fine sediment. The fine sediment was primarily confined to pool areas.

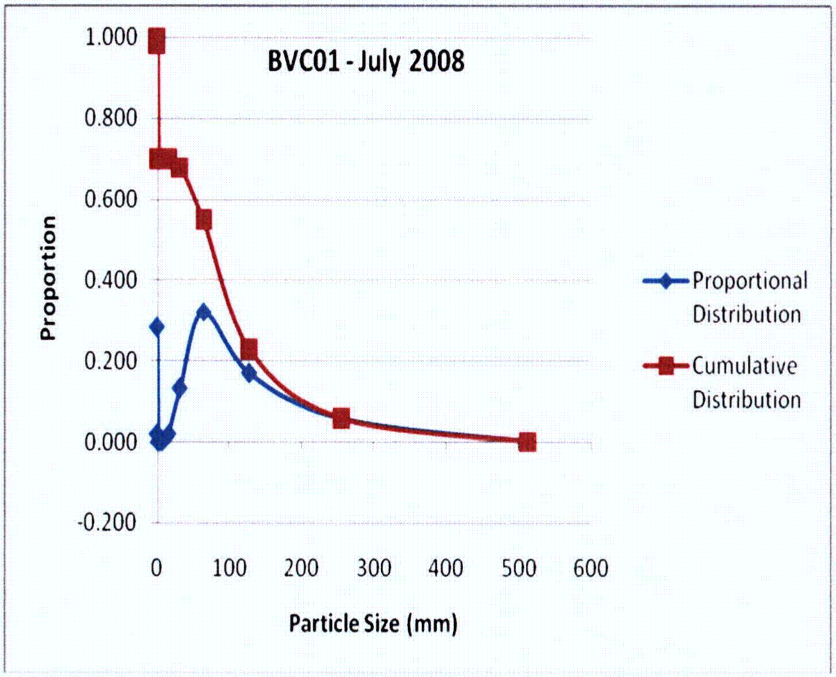


Figure 2.8-9: Cumulative and Proportional Sediment Particle Distribution at Site BVC01, Transects 1 through 11 Combined, April 2008

Beaver Creek is significantly incised along the BVC01 reach, although bank height was generally lower than at the upstream (BVC04) site. Bank slumpage was observed at nine transects and erosion at seven of the eleven transects in this reach. The wetted stream width during the April survey was 3.5 to 7.8 meters; bank-full width ranged from 6.5 to 10.2 meters; and the width at the top of bank was 12.0 to 17.4 meters. Bank height was 1.3 to 2.0 meters. Riparian land use is rangeland with no riparian buffer, cattle have access to the stream, especially in the vicinity of the bridge and transect 1. Woody vegetation is nearly absent from the vicinity of BVC01 and no woody debris was observed in the BVC01 survey reach.

Examples of channel dimensions in pool, riffle, and run habitat types are shown in Figures 2.8-10, 2.8-11, and 2.8-12 below.

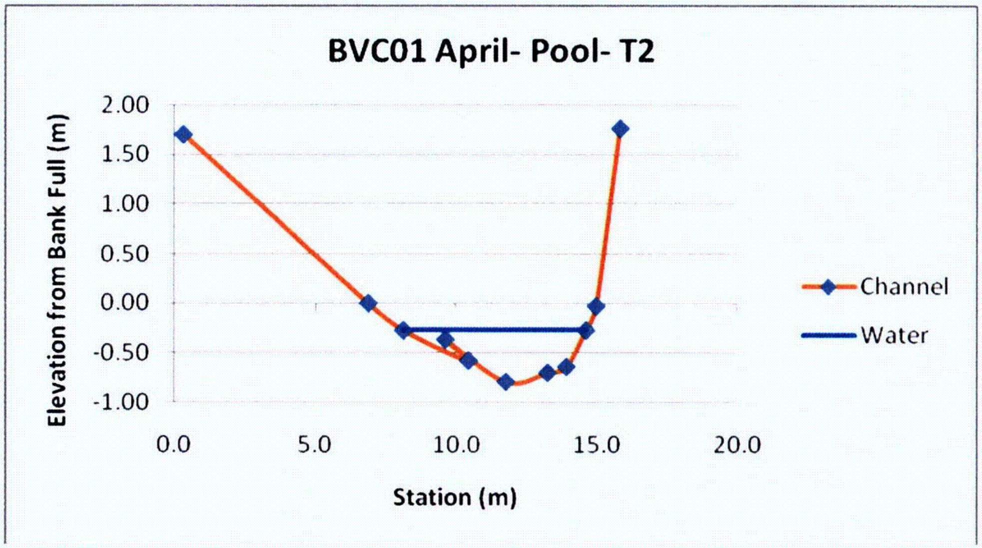


Figure 2.8-10: Channel Dimensions in Pool Habitat, Transect 2

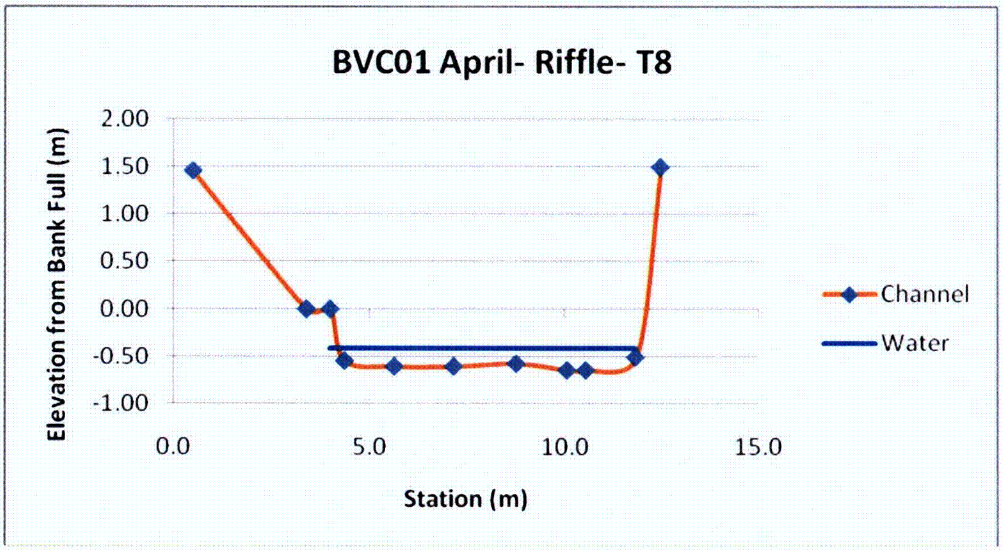


Figure 2.8-11: Channel Dimensions in Riffle Habitat, Transect 8

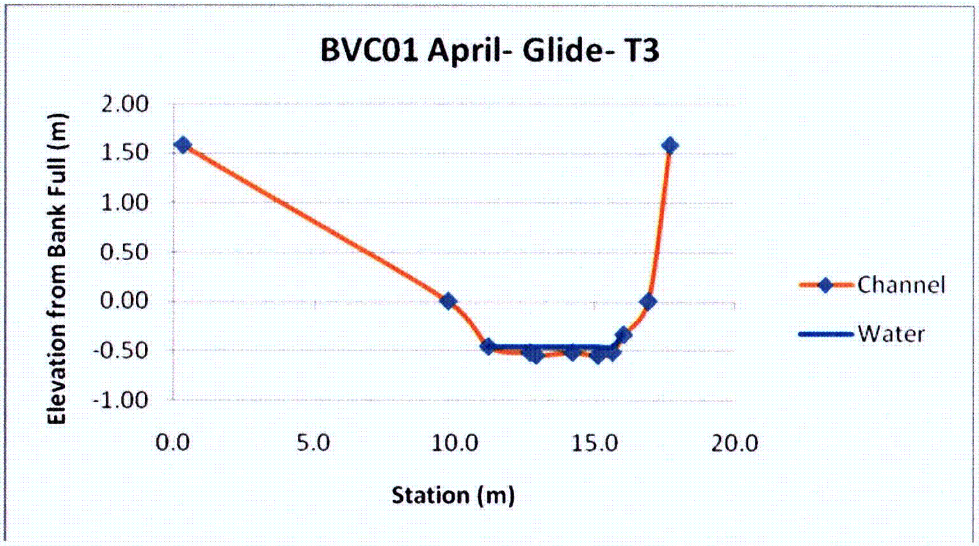


Figure 2.8-12: Channel Dimensions in Glide Habitat, Transect 3

Pools in reach BVC01 were not as deep or long as those in BVC04 and therefore were less conducive to fine sediment deposition. Due to shallow pool depth and lack of cover, pool quality was poor.

July

In July, 2008, the channel dimensions were essentially the same as measured during April, with some localized changes. The high flows that Beaver Creek experienced between the April and July field visits appeared to have resulted in somewhat less fine sediment in the pools. Stream discharge in July was 7.5 cfs, approximately 48 percent higher than in April. In both April and July, discharge was higher at the upstream site (BVC04) than at the downstream site (BVC01). The average wetted width 6.2 meters in April and 7.5 meters in July.

In July the air temperature at BVC01 a water temperatures of 24° C was recorded at 9:20 AM. Although trees were generally bare in April and fully leafed-out in July, the one tree in the riparian buffer was too far from the stream to provide shade to the wetted portion of the channel.

Within the BVC01 survey reach, habitat included 2 pools, 1 glide, and 2 riffles during July. The total length of riffles was 70.8 meters. This represented a change from what was observed in April that was due to increased flow and probably some redistribution of gravel substrate in the channel during high flows.

In contrast to April conditions, very little silt was observed within BVC01 during July. Where fine sediment was present it was restricted to slow moving water in pools and along banks. The cumulative and proportional particle distribution of sediment for the BVC01 reach during the summer survey is shown in Figure 2.8-13, demonstrating the dominance of gravel in the particle size distribution.

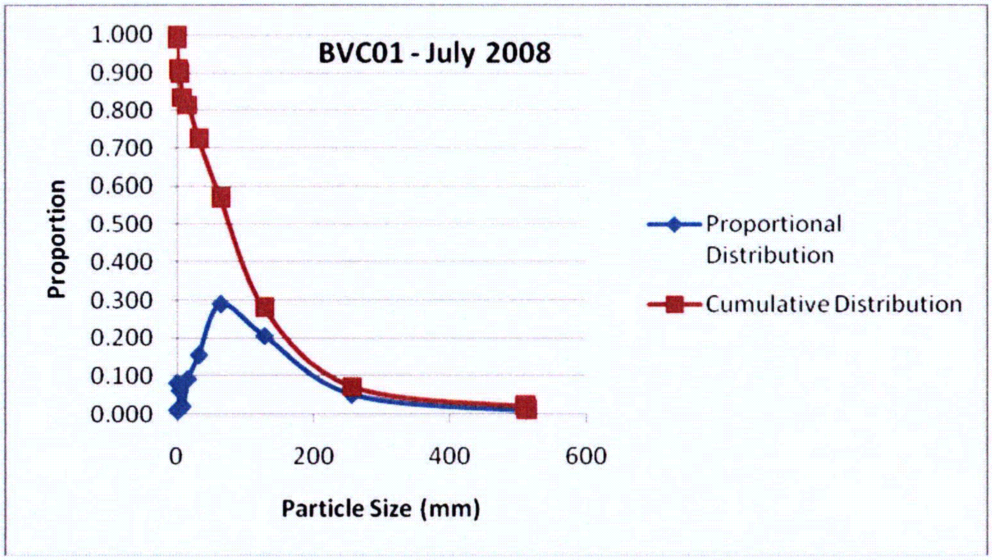


Figure 2.8-13: Cumulative Sediment Particle Distribution at Site BVC01, Transects 1 through 11 Combined during July

Large wood in the reach was essentially absent in July as in April.

The wetted stream width during the summer survey was 4.1 to 8.2 m; bank-full width ranged from 6.8 to 11.3 m; and the width at the top of bank was 12.6 to 18.9 m. Bank height was 1.5 to 2.8 m.

As mentioned previously, pools were considered poor due to lack of depth and cover. Emergent rushes (*Juncus* spp.) and submerged stonewort (*Chara* spp.) were observed growing along the banks in pools during the July survey providing some cover for small fish and substrate for aquatic invertebrates.

2.8.5.6.1.2.2 Habitat/Species Relationships

Benthic Invertebrates

Benthic invertebrates can be useful indicators of habitat quality, providing an index of quality that is integrated over time. Different taxa of aquatic invertebrates (primarily insects, crustaceans, and mollusks) exhibit different habitat requirements, feeding strategies, and tolerances to environmental perturbation. Therefore, there are several metrics of benthic invertebrate community composition that are indicative of aquatic habitat quality. Several of the most indicative and most commonly described of these metrics are summarized in Table 2.8-24.

The invertebrate communities sampled indicate poor habitat conditions in Beaver Creek. The counts of each taxa are shown in Table 2.8-25, and a synopsis of the Community composition metrics is shown in Table 2.8-26. The total number of invertebrates and the taxonomic richness (number of species) were both very low at both Beaver Creek sites. Ephemeroptera (mayflies) and plecoptera (stoneflies) were absent from both sites, indicating an impaired condition. Most taxa collected were moderately tolerant taxa. One individual of a sensitive taxa, *Lepidostoma*, and one individual of a very tolerant taxa, *Culiciodes*, were collected at the downstream site (BVC01) in April. All other taxa collected are considered moderately tolerant.

Table 2.8-24: Benthic Invertebrate Community Composition Metrics and Predicted Direction of Response to Perturbation

Category	Metric	Definition	Predicted response to increasing perturbation
Richness measures	Total taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
	Ephemeroptera taxa	Number of mayfly taxa (usually genus or species level)	Decrease
	Plecoptera taxa	Number of stonefly taxa (usually genus or species level)	Decrease
	Trichoptera taxa	Number of caddisfly taxa (usually genus or species level)	Decrease
Composition measures	% EPT	Percent composite of mayfly, stonefly, and caddisfly taxa	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/Intolerance measures	No. of Intolerant taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
	% Tolerant organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase
Feeding measures	% Filterers	Percent of the macrobenthos that filter fine organic particulate matter from the water column or sediment.	Variable
	% Grazers and Scrapers	Percent of the macrobenthos that scrape or graze upon periphyton	Decrease
Habitat measures	Number of clinger taxa	Number of taxa of clinging insects	Decrease
	% Clingers	Percent of insects having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease

Source:Barbour et al. 1999

Table 2.8-25: Benthic Macroinvertebrate Counts for Composite Samples Collected April and July 2008

	Site and Date			
	BVC01	BVC04	BVC01	BVC04
Taxa	14-Apr-08	14-Apr-08	9-Jul-08	9-Jul-08
Phylum:Mollusca Class:Gastropoda Order: Bassommatophora Family: Physidae	2		2	1
Phylum: Arthropoda Class: Insecta Order: Diptera Family: Ceratopogonidae Genus: *Culiciodes*	1			
Family: Chironomidae Subfamily: Orthocladiinae	14	33		2
Subfamily: Chironomnae		11		1
Subfamily: Tanypodinae			4	23
Family: Siluliidae Genus: *Simulium*	2			1
Order: Trichoptera Family: Hydropsychidae Genus: *Cheumatopsyche*				76
Family: Lepidostomadtidae Genus: *Lepidostoma*	1			
Family: Limnephilidae Genus: *Limnephilus*	3	2		
Order: Coleoptera Family: Elmidae			1	3

Table 2.8-26: Community Composition Metrics for Benthic Macro-invertebrates Collected at the Beaver Creek Sites

							Abundance			
			Functional Feeding Group		Habitat/ Behavior		BVC01	BVC04	BVC01	BVC04
Measures	Taxa	Tolerance	Primary	Secondary	Primary	Secondary	April	April	July	July
Taxa	Physidae	8	SC				2		2	1
	Culicoides	10	PR	GC	bu		1			
	Orthocladiinae	5	GC		bu		14	33		2
	Chironominae	6	GC					11		1
	Tanypodinae	7	PR		bu				4	23
	Simulium	6	FC				2			1
	Cheumatopsyche	5	FC							76
	Lepidostoma	1	SH				1			
	Limnephilus	5	SH		sp		3	2		
	Elmidae (early instar)	4	GC		cn	bu			1	3
Abundance	Abundance						23	46	7	107
Richness	Total Taxa						6	3	3	7
	EPT Taxa						3	1	0	1
	Ephemeroptera Taxa						0	0	0	0
	Plecoptera Taxa						0	0	0	0
	Trichoptera Taxa						3	1	0	1
Composition	% EPT Taxa						17.4%	4.3%	0.0%	71.0%
	% Ephemeroptera						0%	0%	0%	0%
Tolerance	Number of Intolerant Taxa						1	0	0	0
	% Tolerant Macrobenthos						13.0%	0.0%	28.6%	0.9%
	% Dominant Taxa						60.9%	71.7%	0.0%	1.9%
Feeding	% Filterers						8.7%	0.0%	0.0%	72.0%
	% Grazers & Scrapers						69.6%	95.7%	42.9%	6.5%
Habitat	Number of Clinger Taxa						0	0	0	0
	% Clingers						0%	0%	20%	3%
Notes:	SC=Scraper, PR = Predator, GC = Gatherer collector, FC = Filterer/collector, SH = Shredder									
	bu = burrower, sp = sprawler, cn = clinger									
	Tolerance scores on scale of 1-10 with 1 being most sensitive, and 10 most tolerant of environmental stressors									

The downstream site, BVC01, had very low abundance, particularly in the July samples. During the month of June 2008, very high flows occurred in Beaver Creek. It is likely that the high flows mobilized a large volume of sediment and probably resulted in considerable scouring of the sediment, particularly at this site. The reduced macro-benthos present in July may have been due, at least in part, to the high flows that occurred in June.

During a year with more moderate flows, the macro-benthos would likely show an increase in abundance and taxonomic richness throughout the growing season, while a year with drought conditions might have no flow in the riffles where the greatest diversity of benthic invertebrates is typically seen.

High pH, conductivity, temperatures and a high volume of fine sediment all may contribute to the de-pauperate invertebrate communities observed in Beaver Creek.

2.8.5.6.1.2.3 Fish

A total of 12 fish species were collected from the three sampling locations: BVC04 – Beaver Creek upstream of the PAA; BVC01 – Beaver Creek downstream of the PAA; and CHR05 – Cheyenne River downstream of the confluence of Beaver Creek. The species, trophic category, and habitat notes are summarized in Table 2.8-27. The abundance (presented as catch per unit effort or fish per meter of stream length), and average sizes of fish are shown in Table 2.8-28. Fish collection data forms are presented in Appendix 2.8-J.

Table 2.8-27: Fish Species and Trophic Categories

Species Code	Common Name	Latin Name	Trophic Category	Notes
SAS	Sand shiner	*Notropis stramineus*	Omnivore	
CRC	Creek chub	*Semotilus atromaculatus*	Primarily carnivorous omnivore	
PLM	Plains Minnow	*Hybognathus placitus*	Primarily herbiverous	Generally in slower water and side channels of turbid streams. Eats benthic algae & other plant material.
CAP	Common carp	*Cyprinus carpio*	Omnivore	Introduced species. Bottom feeder.
LND	Longnosed dace	*Rhynichthys cataractae*	Primarily carnivorous omnivore	Primarily in riffles
FHM	Fathead minnow	*Pimephales promelas*	Primarily herbiverous	Widely cultivated for bait, and extensively used in toxicological studies
RIC	River Carpsucker	*Carpoides carpio*	Bottom feeding omnivore	
SHR	Shorthead Redhorse Sucker	*Moxostoma macrolepidotum*	Bottom feeding carnivore	
CHC	Channel Catfish	*Ictalurus punctatus*	Bottom feeding omnivore	Species most likely to be eaten by humans.
PLT	**Plains topminnow**	***Fundulus sciadicus***	**Surface feeding carnivore**	
PLK	Plains Killifish	*Fundulus zebrinus*	Surface feeding carnivore	
GRS	Green sunfish	*Lepomis cyanellus*	Carnivore	Palatable but generally too small for human consumption

Bold species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

Table 2.8-28: Summary of Fish Size and Abundance

Location	Date	Common Name	CPUE (fish/m)	Average total length (mm)	Average weight (g)
CHR05 – Cheyenne River at Marietta	4/15/08	Green sunfish	0.01	98	20
		Sand shiner	0.53	48	4.6
		Creek chub	1.00	47	0.9
		River Carpsucker	0.01	97	13
		Shorthead Redhorse Sucker	0.14	145	115
		Plains topminnow	**0.01**	**51**	**<1**
		Plains killifish	0.48	49	1.5
CHR05 – Cheyenne River at Marietta	7/09/08	Common carp	0.01	135	31
		Longnosed dace	0.01	74	4
		Fathead minnow	0.10	47	0.7
		Sand Shiner	0.45	49	1.5
		Shorthead Redhorse Sucker	0.14	153	39
		River Carpsucker	0.04	407	1,038
		Channel catfish	0.03	222	88
		Plains killifish	0.07	58	1.9
BVC01 – Beaver Creek at Argentine Road	4/16/08	Fathead minnow	0.64	48	1.3
		Plains killifish	0.02	45	4
		Longnosed dace	0.01	48	<1
		Green sunfish	0.01	120	25
BVC01 – Beaver Creek at Argentine Road	7/10/08	Common carp	0.01	171	73
		Sand Shiner	0.10	50	1.1
		Fathead minnow	0.33	50	1.5
		Longnosed dace	0.01	59	2
		Plains minnow	0.01	73	1
		Plains topminnow	**0.06**	**56**	**2**
		Plains killifish		60	1.8
BVC04 – Beaver Creek at old Hwy 85 Bridge	4/16/08	Common carp	0.03	75	9.3
		Fathead minnow	0.84	45	1.1
		Channel catfish	0.01	215	72
		Plains killifish	0.10	44	1.4
		Green sunfish	0.04	66	7.5
BVC04 – Beaver Creek at old Hwy 85 Bridge	7/10/08	Common carp	0.01	260	230
		Sand Shiner	0.26	52	1.3
		Fathead minnow	0.47	50	1.4
		Longnosed dace	0.02	63.5	2.5
		Shorthead redhorse sucker	0.01	136	130
		Plains killifish	0.09	55	1.4

Notes: 1CPUE = Catch per unit effort.

Bold species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

2.8.5.6.1.2.3.1 Locally Significant Fish Species

Recreational anglers fish Beaver Creek, although the Cheyenne River and Angostura Reservoir provide greater fishing opportunities in the area. Channel catfish is the species most likely to be caught and eaten from Beaver Creek.

Hampton (1998) calculated the relative weight index (Wr) for channel catfish in the Cheyenne River to assess the condition of this species in the Cheyenne River. Hampton (1998) reported a curvilinear relationship between weight and length (Ws=63.75 +5,780/L where Ws= standard weight, and L= total length). Comparing the weight/length ratio of channel catfish collected in this study to the standard weight (Ws) described above, the relative weight (Wr=100*W/Ws) can be used as an indicator of fish condition. Generally, relative weights greater than 100 indicate better than average condition and those less than 100 indicate poorer than average condition. The weight of the largest (290 mm) channel catfish collected from the Cheyenne River had a very high relative weight (Wr = 198) while the other catfish collected from the Cheyenne River had low relative weights (Wr = 51 and 52), and the one channel catfish collected from Beaver Creek (at BVC04) had a moderately low relative weight (Wr=79). Although the average Wr for the Cheyenne River channel catfish (100.8) indicates good agreement with Hampton's (1998) modeled relationship, the weight/length ratio of individual fish varied considerably. A larger sample size would be needed to draw any conclusions about the relative condition of fish from these sites.

Relative weights are shown in Table 2.8-29 below.

Table 2.8-29: Relative weight index for channel catfish collected at Beaver Creek and Cheyenne River

Site	Date	Length	Weight	Standard Weight (Ws)	Relative Weight (Wr)
BVC04	Apr-08	215	72	90.6	79.4
CHR05	Jul-08	290	166	83.6	198.4
CHR05	Jul-08	186	50	94.8	52.7
CHR05	Jul-08	181	49	95.6	51.2
CHR05 Average					100.8

2.8.5.6.1.2.3.2 Threatened and Endangered Aquatic Species

No threatened or endangered aquatic species are known to inhabit Beaver Creek, particularly within 1.0 mile of the permit boundary.

2.8.5.6.1.2.4 Radiological Testing

The channel catfish was the only species collected in April that contained detectable uranium (0.05 mg/kg, and 3×10^{-5} μCi/kg) (Table 2.8-30). This species was collected from the downstream Beaver Creek site (BVC04). In July, channel catfish were collected from the Cheyenne River site (CHR05). The channel catfish is the only species collected in the PAA that is typically caught for human consumption.

Uranium was detected in all of the fish collected in July 2008 due, in large part, to increased sample sizes (Table 2.8-30). As indicated, April samples showed little, if any, detectable uranium, however, the detection limits were higher during that sampling effort due to matrix interference. Therefore, it is not possible to determine if there was an actual seasonal difference in fish tissue uranium concentration. Uranium concentrations and uranium radioactivity were generally low and similar across sample sites when compared by species. Radioactivity from Polonium-210, Thorium-230, and Radium-226 was detectable, but low in most samples. Lead-210 was only detected in one specimen (plains killifish [*Fundulus zebrinus*]) collected in April at the downstream Beaver Creek site (BVC01). Although this measurement was relatively high (0.02 μCi $\pm$0.02 μCi), it should be noted that, due to matrix interference, the precision was limited on this sample. Lead-210 was not detected in any of the other samples.

Table 2.8-30: Beaver Creek Baseline Radiological Analysis of Whole Fish

Site	Species	No.	Length[a] mm	Sample Weight[b] g	U mg/kg	U uCi/Kg	Po 210 uCi/Kg	Pb 210 uCi/Kg	Th 230 uCi/Kg	Ra 226 uCi/Kg
BVC01 - April	GRS	1	120	22.96	ND	ND	u	u	u	0.0003
	PLK	1	48	1.77	ND	ND	u	0.02[c]	0.0002	u
	LND	1	48	0.64	ND	ND	0.002	u	0.0001	u
	FHM	1	30-60	4	ND	ND	0.0004	u	u	u
BVC04-April	PLK	1	40-60	0.72	ND	ND	u	u	u	u
	RIC	1	111	18.79	ND	ND	0.0004	u	0.00002	u
	GRS	1	50	2.16	ND	ND	0.0006	u	0.0008	u
	FHM	1	30-70	~1.2	ND	ND	u	u	0.00001	0.0004
	CHC	1	215	72	0.05	30	0.0009	u	0.00002	u
CHR05-April	RIC	1	97	13.73	ND	ND	0.0008	u	u	u
	GRS	1	98	13.67	ND	ND	0.00008	u	0.00001	u
	SRS	1	169	55.05	ND	ND	0.0002	u	0.00002	u
	CRC	1	30-70	2.92	ND	ND	u	u	u	u
	PLK	1	32-74	1.51	ND	ND	u	u	0.0001	u
	SAS	1	30-60	1.51	ND	ND	u	u	0.001	u
BVC01-July	FHM	5	42-67	~8	0.026	0.000018	0.0004	u	u	u
	CAP	1	171	73	0.0098	0.0000067	0.00078	u	u	u
	SAS	5	46-62	7	0.031	0.000021	0.00023	u	0.000098	u
	PLK	5	57-71	9	0.035	0.000024	0.00047	u	u	u
	PLT	5	48-71	12	0.021	0.000014	0.00035	u	0.0001	u
BVC04-July	SAS	5	45-58	~6.7	0.024	0.000016	0.00054	u	0.000027	u
	FHM	5	42-61	~3.7	0.031	0.000021	0.00018	u	u	u
	CAP	1	260	237	0.014	0.0000094	0.00015	u	0.0000023	u
	PLK	5	48-68	~7.2	0.019	0.000013	u	u	0.000094	u
	SRS	1	136	130	0.0072	0.0000049	0.00017	u	u	u
CHR05-July	FHM	5	38-60	~0.7	0.024	0.000016	0.00042	u	u	u
	SAS	5	42-60	~1.5	0.04	0.000027	0.00049	u	0.00014	u
	CAP	1	135	31	0.01	0.0000069	0.00074	u	0.000017	u
	RIC	4	381-415	5150	0.031	0.000021	u	u	u	0.000008
	SRS	2	146-160	78	0.0066	0.0000044	0.00005	u	0.0000032	u
	PLK	4	46-68	~7.4	0.017	0.000012	0.00047	u	u	u
	CHC	3	181-290	265	0.017	0.000012	0.00016	u	0.000009	u

Notes: GRS = Green Sunfish, PLK = Plains Killifish; LND = Longnosed Dace; RIC = River Carpsucker; FHM = Fathead Minnow; CHC = Channel Catfish; SRS = Shorthead Redhorse Sucker; CRC = Creek Chub; SAS = Sand Shiner. U = Uranium; Po = Polonium; Pb = Lead; Th = Thorium; RA = Radium. ND = Not Detected at the reporting limit, u = Not detected at minimum detectable concentration. [a]Lengths reported as a range when multiple specimens were combined as a composite sample, or when the individual processed for radiology was not recorded separately. [b] Approximate sample weights from field average weights for the species measured in the field. [c]Due to matrix interference, the precision of this measurement was equal to the detected concentration (i.e. 0.02 μCi ± 0.02 μCi).

2.8.5.7 References

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong, 1994 "*Mammals of Colorado*" Denver Museum of Natural History, Denver, Colorado.

Hampton, D.R., 1998, "*A Survey of the Fishes and Habitat of the Cheyenne River in South Dakota*".

Hollenbeck, Mark, Project Manager, Powertech Uranium Corporation, Powertech (USA) Inc., "*Personal Communication*".

Jones Jr., J.K, D.M. Armstrong, R.S. Hoffmann, and C. Jones, 1983, "*Mammals of the northern Great Plains*", University of Nebraska Press, Lincoln, NE.

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

Personal Communication with Michals, Stan, Wildlife Division - Energy and Minerals Coordinator, South Dakota Game, Fish, and Parks, 2008, White paper: "*Prairie Stream Sampling – Summary. South Dakota Department of Game, Fish, and Parks, Region 1*".

South Dakota Department of Environment and Natural Resources (SDDENR), 2002, "*Field Operations Manual for Physical Habitat Characterization of Wadeable Streams*", Water Resources Assistance Program, July.

South Dakota Department of Parks, Fish & Game (SDDPFG), Undated, "*Prairie Stream Sampling, Region 1*", 2 pages.

Tennessee Valley Authority, 1979, "*Draft Environmental Statement for the Edgemont Uranium Mine*".

US Department of Agriculture, Natural Resources Conservation Service (NRCS), 2006, ftp://ftp-fc.sc.egov.usda.gov/WY/CSP/beaverdata.pdf

US Environmental Protection Agency (EPA), 2008, "*Section 303(d), List Fact Sheet for Watershed BEAVER*", Last updated May 9, 2008, Available: http://iaspub.epa.gov/tmdl/huc_rept.control?p_huc=10120107&p_huc_desc=BEAVER Accessed: May 9, 2008.

U.S. Environmental Protection Agency, 1993, "*Ecoregions of the United States*", Derived from J. W. Omernik; "*Ecoregions of the Coterminous United States; Scale 1:7,500,000*", Annals of the Association of American Geographers 77:118-125.

U.S. Nuclear Regulatory Commission (NRC), 2003, "*Environmental Review Guidance for Licensing Actions Associated with NMSS Programs, Final Report*", Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C, August.

2.9 Baseline Radiologic Characteristics

2.9.1 Introduction

This section provides baseline radiological data for surface soils (0-5 and 0-15 cm), subsurface soils to a depth of 1 meter, vegetation, locally grazed cattle, direct radiation, radon-222 in air; and radon-222 flux rates representative of the project property. The work was performed by Environmental Restoration Group (ERG) between August 2007 and July 2008.

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

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

The baseline radiological field investigation consisted of the following activities:

- A GPS-based gamma survey conducted at 100 to 500 m transects spanning the PAA.
- A second GPS-based gamma survey of two, collective land application areas conducted at 100 m transects.
- Collecting surface soil (0-15 cm) samples at 75 randomly selected and at five biased locations spanning the PAA.
- Collecting subsurface soil samples at nine randomly selected locations taken at depth intervals of 15-30 cm and 30-100 cm.
- Collecting surface (0-15 cm) and subsurface samples at the same depth intervals at 17 randomly selected locations in the land application areas.
- Collecting shallow (0-5 cm) surface soil samples at the eight Air Monitoring Stations (AMS).
- Vegetation sampling at each AMS during the summer, fall and spring.
- Air monitoring at one background and seven additional locations.
- Radon monitoring in air.
- Radon flux measurements at locations coinciding with the subsurface samples.
- Exposure rate monitoring, using a High Pressurized Ion Chamber (PIC) and thermoluminescent detectors (TLDs).
- Collecting three samples of locally grazed livestock.

Table 2.9-1 summarizes the scope of the field investigation. All samples were shipped under chain-of-custody to a National Environmental Accreditation Conference-certified laboratory, Energy Laboratories, in Rapid City, South Dakota.

The units reported in the body, tables, and figures related to this section vary. NRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills*, has specific requirements for unit reporting in tables. For example, it recommends that radionuclide soil concentrations be reported in units of microcuries per gram (μCi/g). Where applicable, the tables adopt this unit. The main body of Section 2.9, however, adopts the unit picocuries per gram (pCi/g) for this parameter, as this unit is used more generally and consistently by the uranium industry and public.

Table 2.9-1: Summary of Baseline Radiological Investigation Scope

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

2.9.1.1 References

Code of Federal Regulations, 10 CFR 40, *"Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content".*

USNRC, 1980, Regulatory Guide 4.14, *"Radiological Effluent and Environmental Monitoring at Uranium Mills, Revision 1"*, U.S. Nuclear Regulatory Commission, April 25.

USNRC, 2003, *"Standard Review Plan for In Situ Leach Uranium Extraction License Applications"*, U.S. Nuclear Regulatory Commission Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material Safety and Safeguards, June.

2.9.2 Gamma Survey

2.9.2.1 Methods

2.9.2.1.1 Baseline GPS-Based Gamma Surveys

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

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

The areas subject to GPS-based gamma surveys are shown on Figure 2.9-1.

POWERTECH (USA) INC.

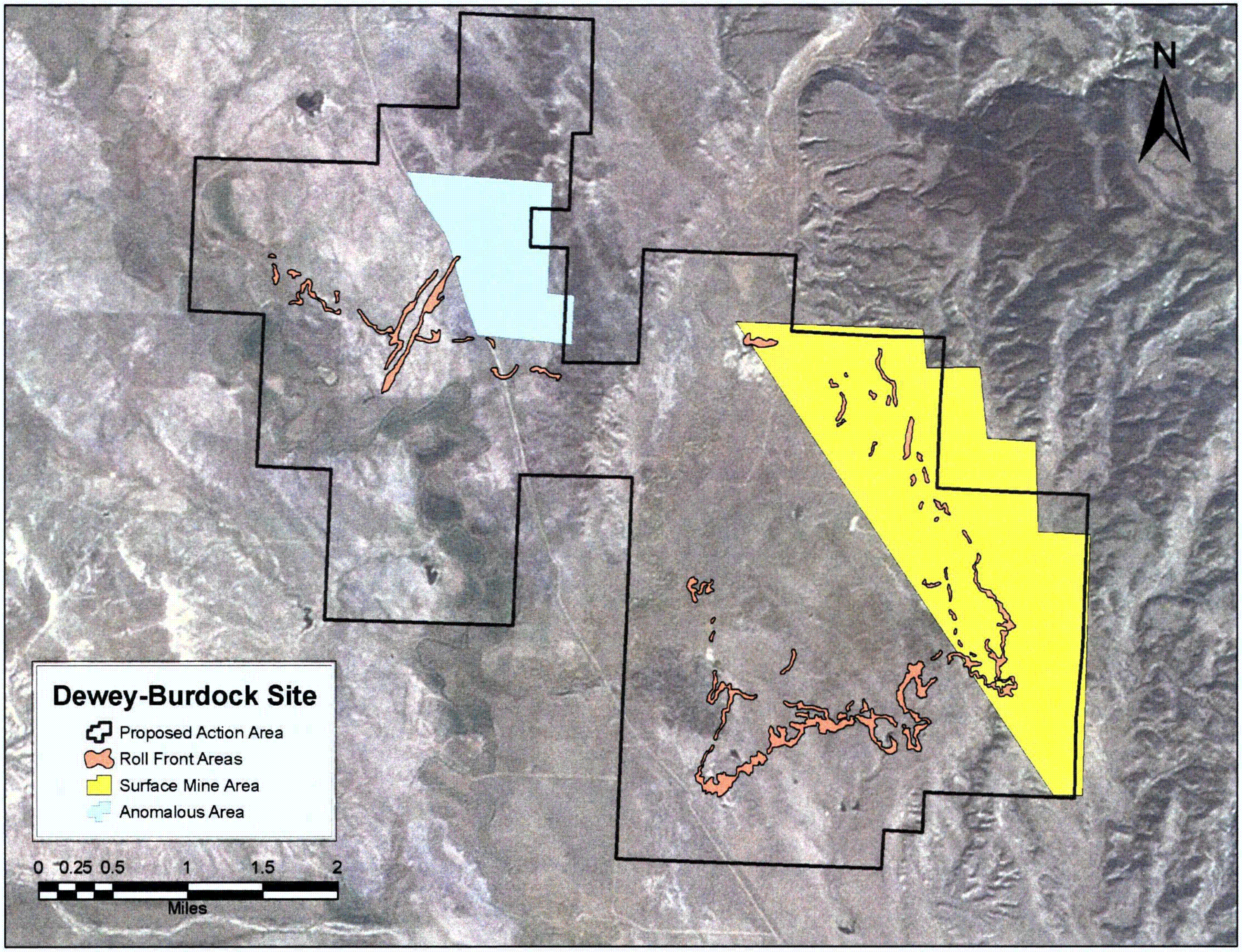


Figure 2.9-1: Areas Subject to GPS-Based Gamma Surveys

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

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

Powertech (USA) collected 12 co-located static gamma counts and exposure rate measurements to develop the correlation between gamma counts and exposure rates. The locations were biased towards areas where gamma shine was not relatively high; that is, where gamma count rates remained relatively constant at 18 in, 1 m, and 2 m above ground surface. In addition, locations were chosen to encompass most of the range of sodium iodide detector readings observed in the GPS-based gamma surveys. The sodium iodide measurements were taken using one of the 2-inch by 2-inch sodium iodide detectors that were used in the baseline gamma survey. A 1-minute integrated count was taken at each of the 12 locations with the detector suspended at 18 in. above the ground surface. Exposure rate measurements were then collected at a 1-m height at each location, directly above the location where the sodium iodide detector was held. Exposure rates were determined after 20-minute integrated counts. The PIC and gross gamma measurements were performed on July 14 to 16, 2008 at the locations shown on Figure 2.9-2.

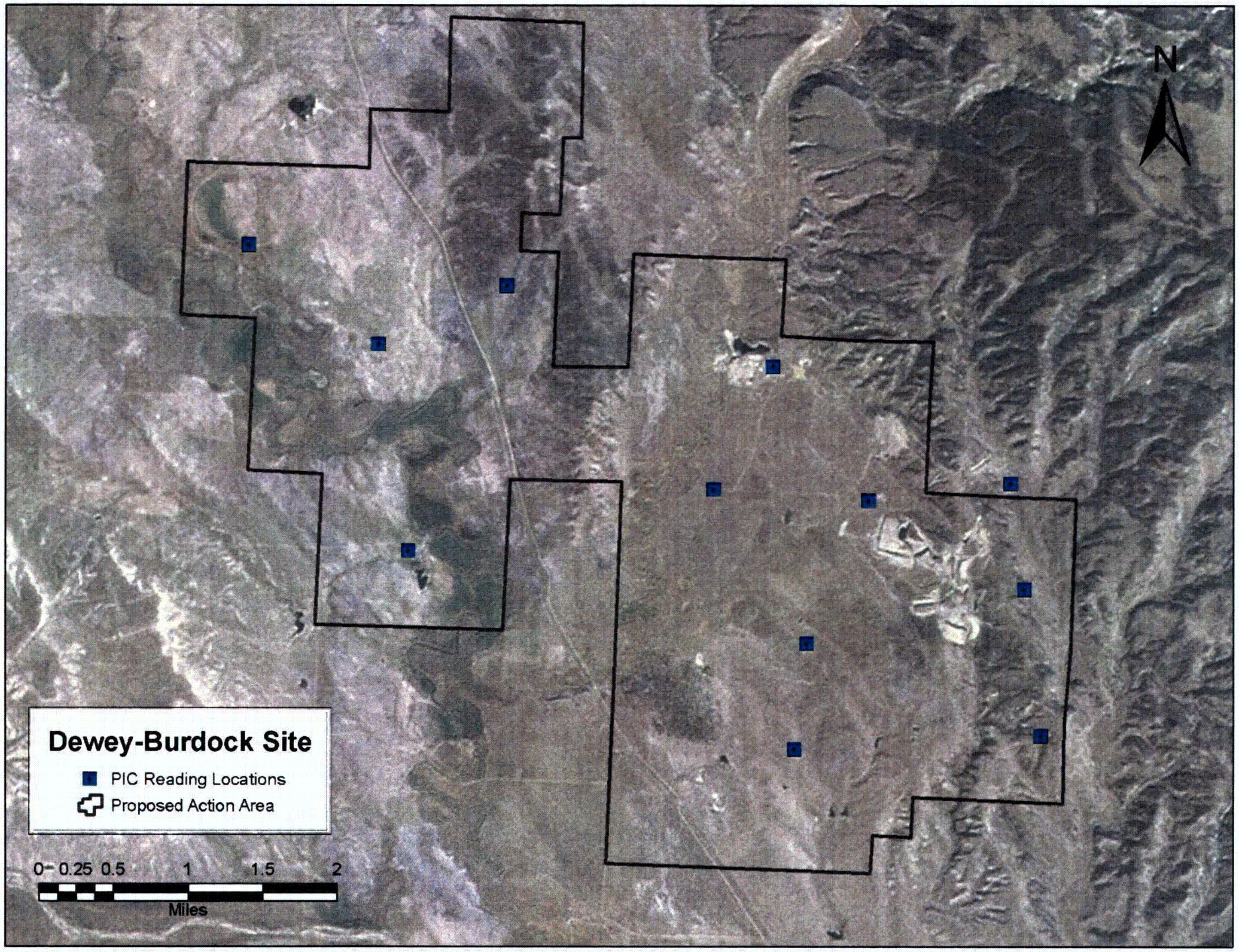


Figure 2.9-2: Locations of High Pressure Ion Chamber and Sodium Iodide Detector Measurements

2.9.2.1.3 Gamma/Radium-226 Correlation Grids

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

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

2.9.2.1.4 Data Quality Assurances/Quality Control

All survey instruments were calibrated. The function of survey instruments was checked at the beginning and end of each work day using a National Institute of Standards and Technology-traceable cesium-137 source. Calibration Sheets and function check data are provided in Appendix A of Appendix 2.9-A.

2.9.2.2 Gamma Survey Results

2.9.2.2.1 Baseline Gamma Survey Results

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

The observed gamma-ray count rates are presented as colors representing ranges of counts in Figure 2.9-3. Three areas are shown on the figure: the main permit and surface mine areas, and an area of anomalous gamma-ray count rates located in the northern portion of the main project area.

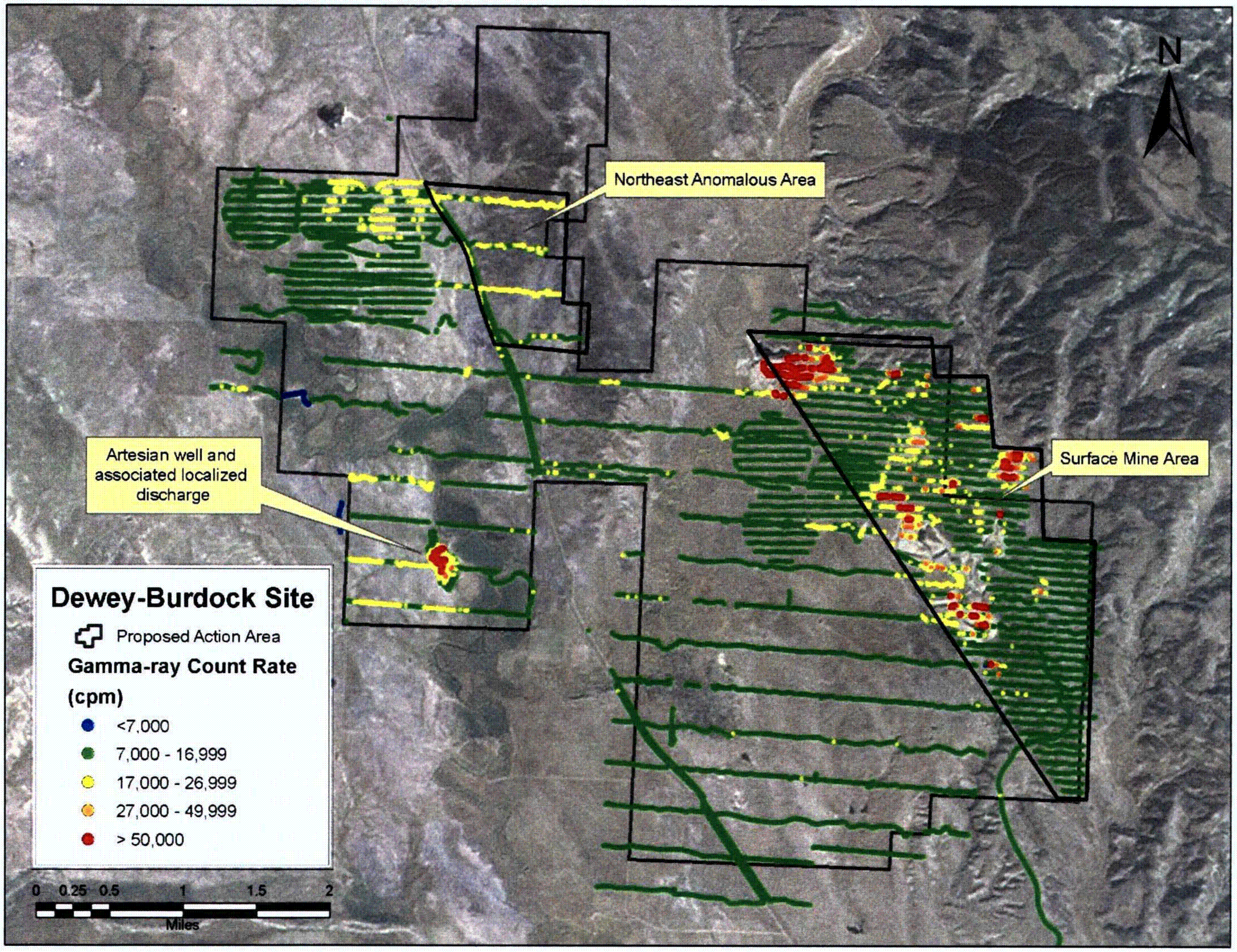


Figure 2.9-3: Gamma-Ray Count Rates Obtained During Initial GPS-Based Gamma Survey

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

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

The summary statistics of the GPS-based gamma-ray survey are listed in Table 2.9-2. The median of the gamma-ray count rates for the overall data set was 12,687 counts per minute (cpm). Field personnel collected 157,075 readings ranging from 5,550 to 460,485 cpm.

Table 2.9-2: Statistical Summary of Gamma-Ray Count Rates in Entire Data Set, Main Permit and Surface Mine Areas

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

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

Main Project Area

As shown in Table 2.9-2, the median gamma-ray count rate for the main project area data set was 12,664 cpm for 71,148 observations. The count rates ranged from 5,883 to 171,243 cpm. Low outliers in the main project area data set, count rates below 7,790 cpm, appear to be limited to two clusters. High outliers in the data set, count rates exceeding 17,946 cpm, appear to be limited to an approximately 600-acre located at the north end of the main project area. The area is identified as an anomalous area on Figure 2.9-1.

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

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

Surface Mine Area

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

Discussion

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

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

Land Application Areas

The summary statistics of the GPS-based gamma-ray survey of the project land application areas are listed in Table 2.9-3. The gamma-ray count rates obtained in the main permit area are listed in the table to facilitate comparison between the land application areas and the larger area in which they occur. The data are shown as ranges of count rates on Figure 2.9-4.

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

Table 2.9-3: Statistical Summary of Gamma-Ray Count Rates in Land Application Areas

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

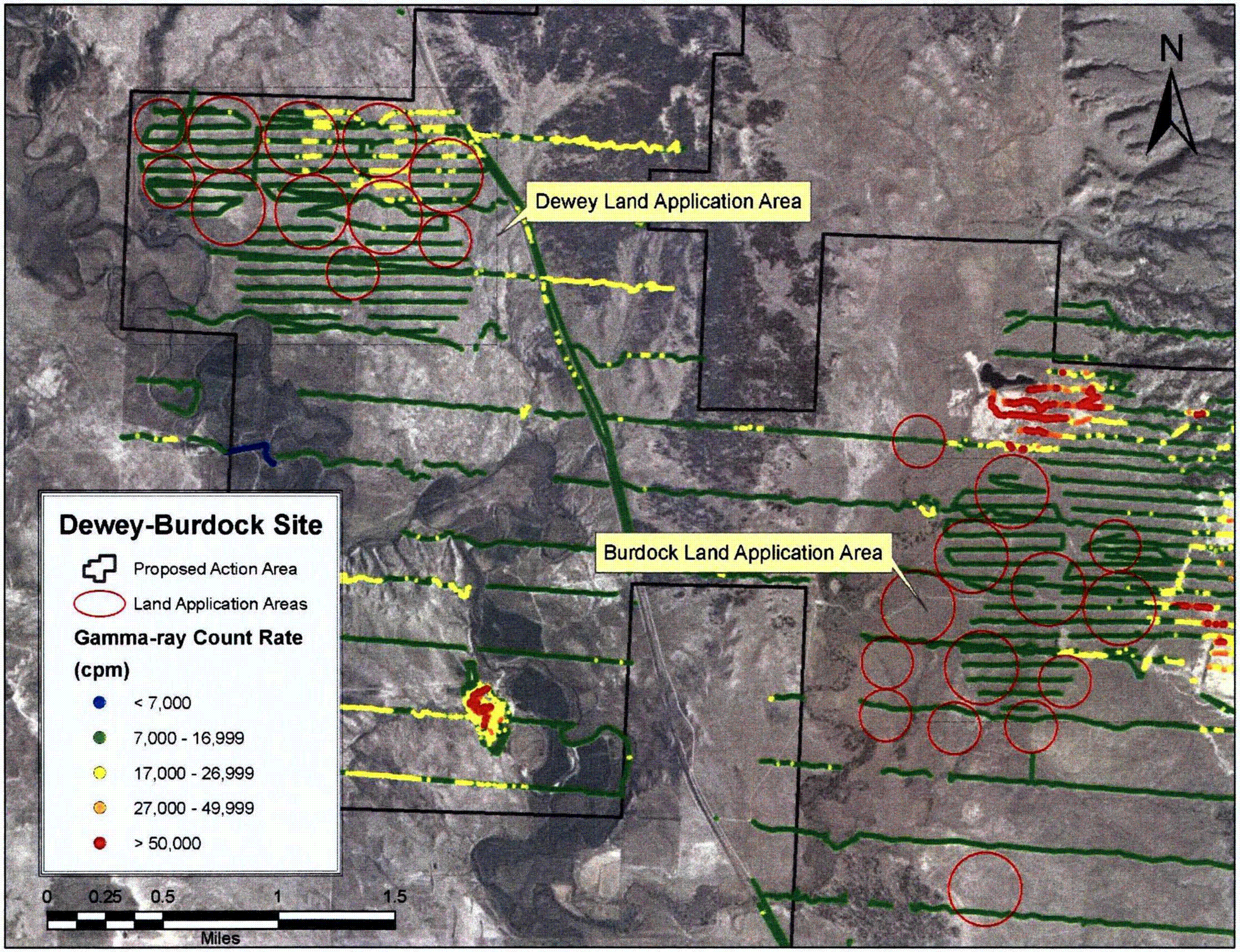


Figure 2.9-4: GPS-Based Gamma-Ray Count Rates in the Land Application Areas

2.9.2.2.2 Results of Cross-Calibration of Sodium Iodide Detectors and High-Pressure Ionization Chamber

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

Exposure Rate = 0.0007 x Gamma Count Rate + 2.02

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

The linear regression model for the average is a good fit, with an R^2 of 0.96. Nearly all of the data align along the slope of the line, as shown in Figure 2.9-5. The correlations are similar for the individual sodium iodide detectors and not discussed further.

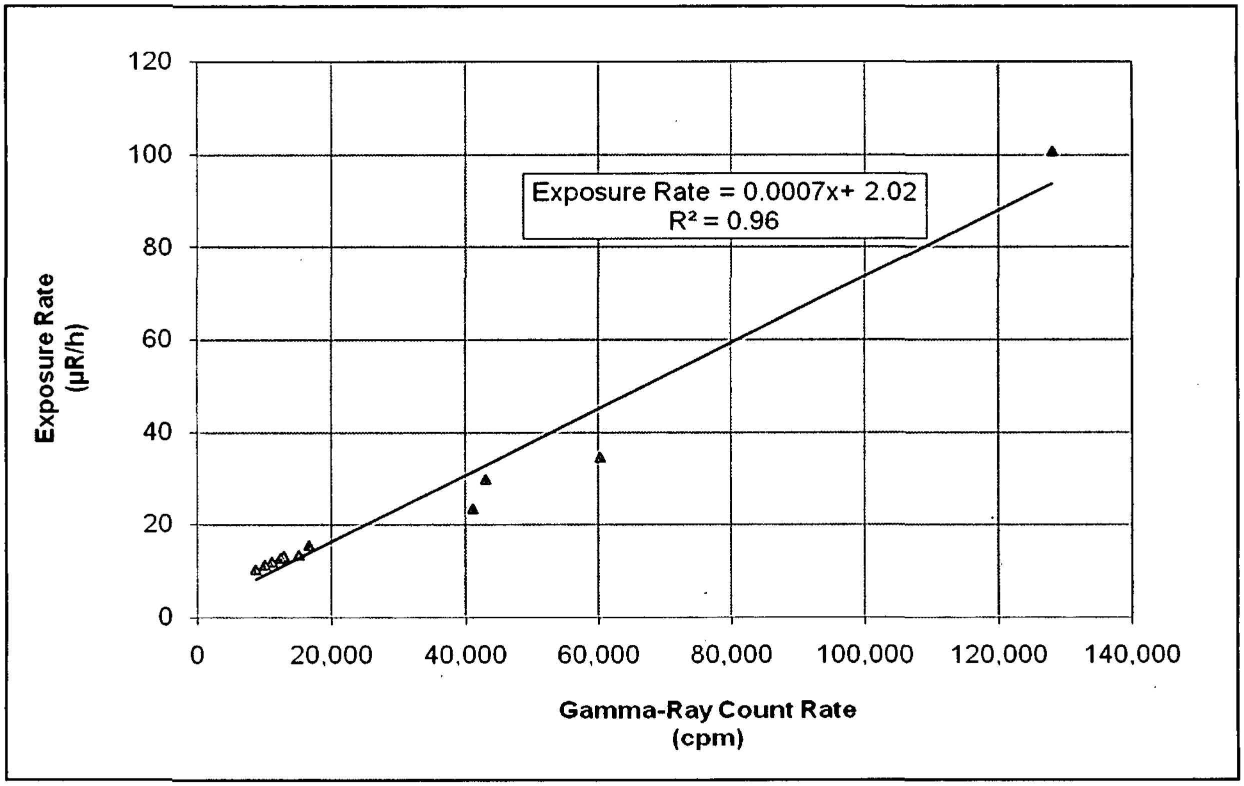


Figure 2.9-5: Linear Regression Model: Exposure Rates Correlated to Gamma-Ray Count Rates

The linear regression model predicts an average exposure rate of 10.9 μR/hr for the site. The range of predicted exposure rates is 5.9 to 324 μR/hr, based on the observed gamma-ray count rates at the site. The predicted site-wide exposure rates are shown as ranges of colors in 700 by 700 ft grid block averages on Figure 2.9-6.

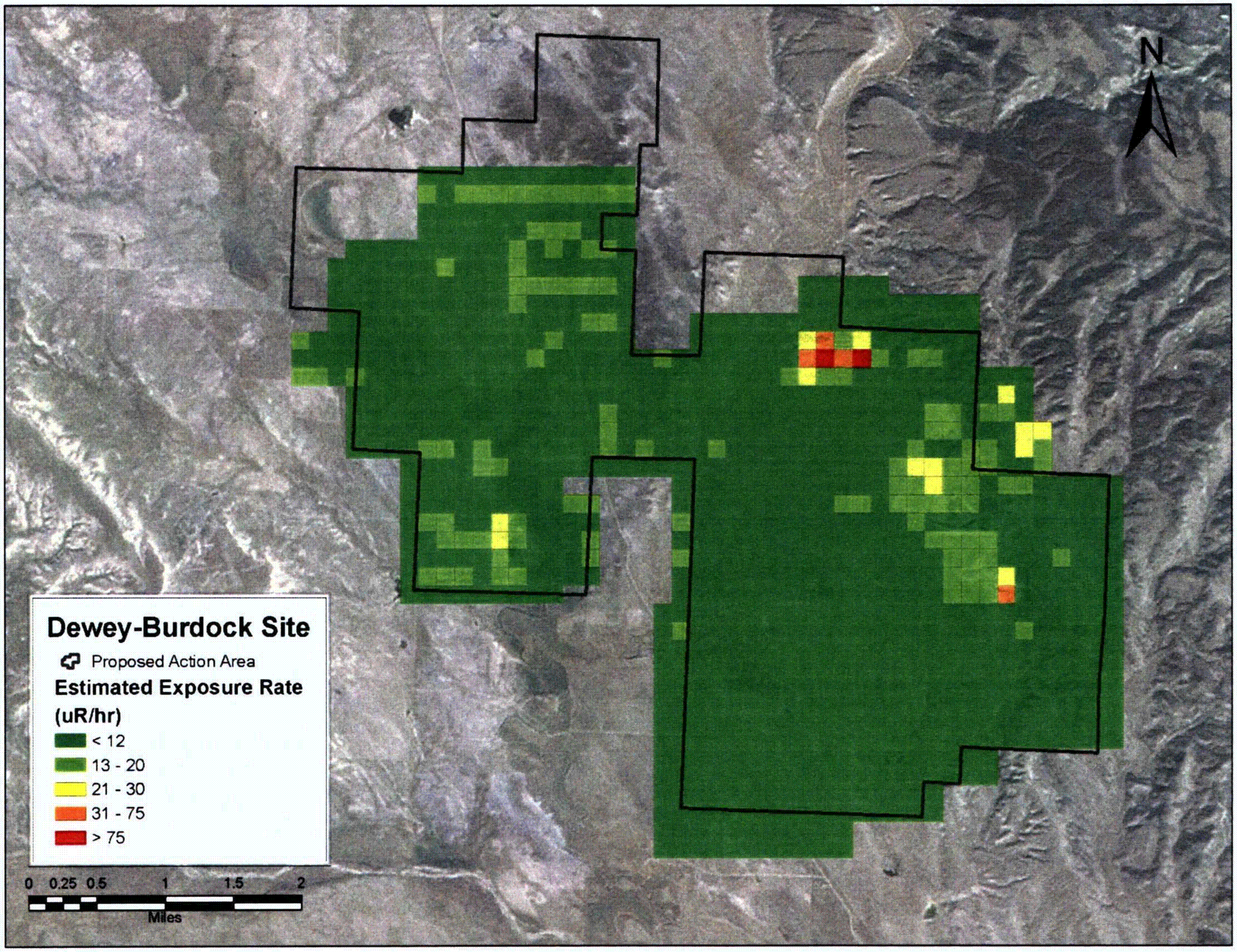


Figure 2.9-6: Predicted Site-Wide Exposure Rates, Grid Block Averages

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

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

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

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

This model has an R^2 of 0.43, with 0.43 accounting for 43 percent of the variance in the data set. Table 2.9-4 lists summary data for the predicted radium-226 concentrations in each of the major areas.

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

Table 2.9-4: Summary of Predicted Radium-226 Concentrations in Grid Blocks

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

2.9.2.2.4 Final Gamma Exposure Rate Mapping

As stated in Section 2.9.2.2.2, the linear regression model correlating sodium iodide detector readings to PIC measurements predicts a site-wide average exposure rate of 10.9 μR/hr. The range of predicted exposure rates is 5.9 to 324 μR/hr, based on the observed gamma-ray count rates at the site. As indicated on Figure 2.9-6, predicted exposure rates ranging from 21 to greater than 75 μR/hr occur in the open pit mine areas, near the artesian well and its localized discharge areas, and in rocky outcrop areas in the northwest corner of the surface mine area. Predicted exposure rates in the anomalous area in the northern portion of the main permit area range from less than 12 to 30 μR/hr.

2.9.2.2.5 Soil Ra-226 Concentration Mapping

Predicted radium-226 concentrations in soil are shown as grid block averages in Figure 2.9-7. It is important to acknowledge that discrepancies between measured soil radium-226 concentrations reported by the laboratory and corresponding radium-226 concentrations estimated by gamma surveys are inevitable in a characterization survey of this nature and magnitude, given the heterogeneity of the site (at least in some areas) and differing detector-source geometry at various sample/survey locations.

At the same time, Figure 2.9-7 shows that without a gamma survey, reliance on a random soil sampling program alone would not have identified elevated areas of radioactivity at the site.

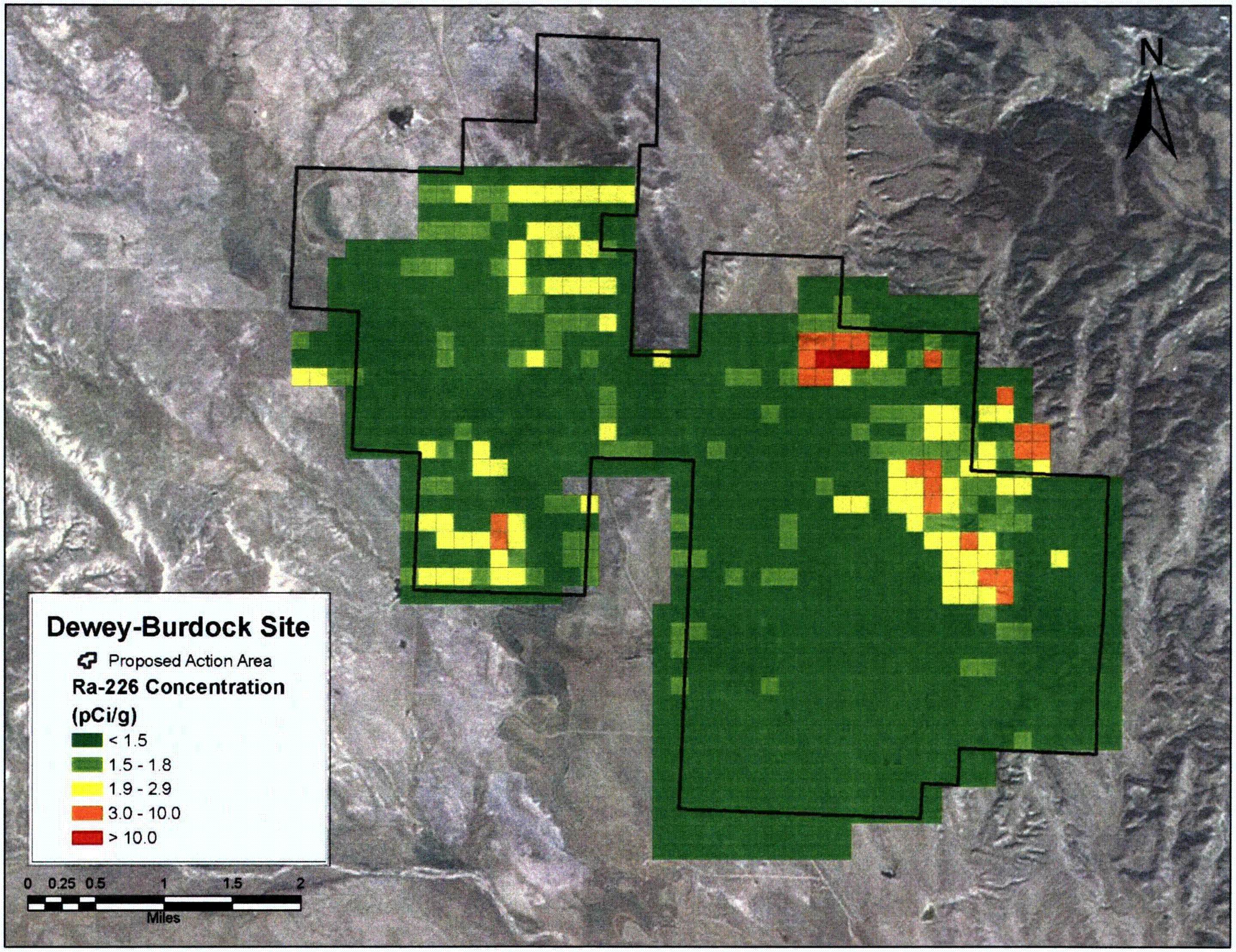


Figure 2.9-7: Predicted Site-Wide Radium-226 Concentrations, Grid Block Averages

2.9.3 Soil Sampling

2.9.3.1 Methods

2.9.3.1.1 Surface and Subsurface Soil Sampling

Two salient guidances were applied to the radiological characterization of the project site. The first is NUREG-1569 "Standard Review Plan (STR) for In Situ Leach Uranium Extraction License Applications (NRC 2003). NUREG-1569 identifies guidance in NRC Regulatory Guide 4.14 (Revision 1), "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC 1980) as the acceptable criteria for pre-operational radiological baseline evaluations.

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

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

Main Permit and Surface Mine Areas

The soil sampling strategy for the main permit and surface mine areas of the project site consisted of biased and random sampling at the eight AMS locations shown in Figure 2.9-8 (this figure also shows the locations of the radon flux and track etch detector measurements, discussed below) and 80 additional locations shown in Figure 2.9-9. Biased samples were collected at 5 of the 80 locations; the remainder was placed randomly, using Visual Sampling Plan (VSP), Version 5.0. The biased samples were obtained in the surface mine area and selected to bound the upper range of radionuclide concentrations. The five biased samples are not sufficient to characterize radium-226 concentrations in impacted areas.

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

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

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

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

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

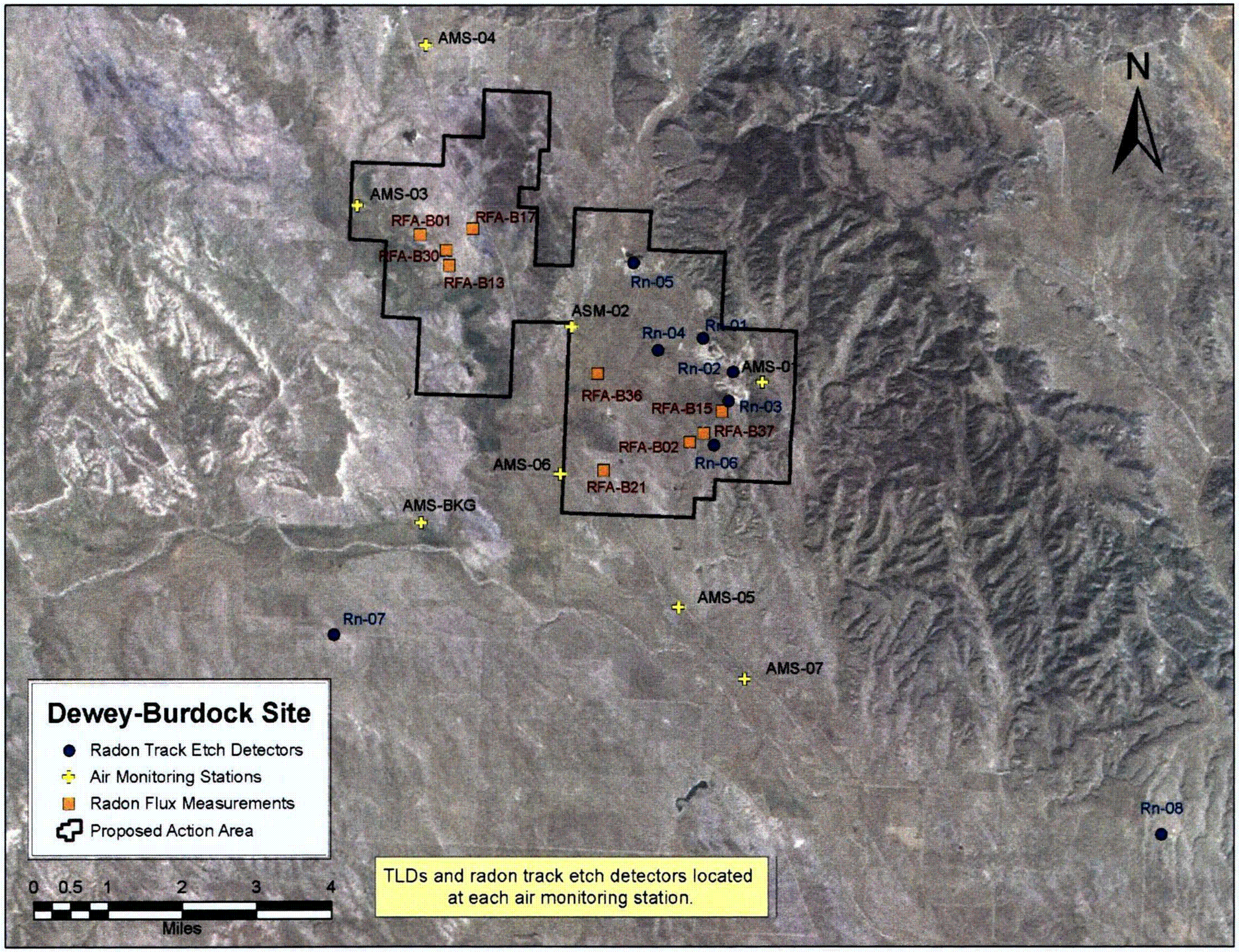


Figure 2.9-8: Air Monitoring Station, Ambient Radon, and Radon Flux Measurement Locations

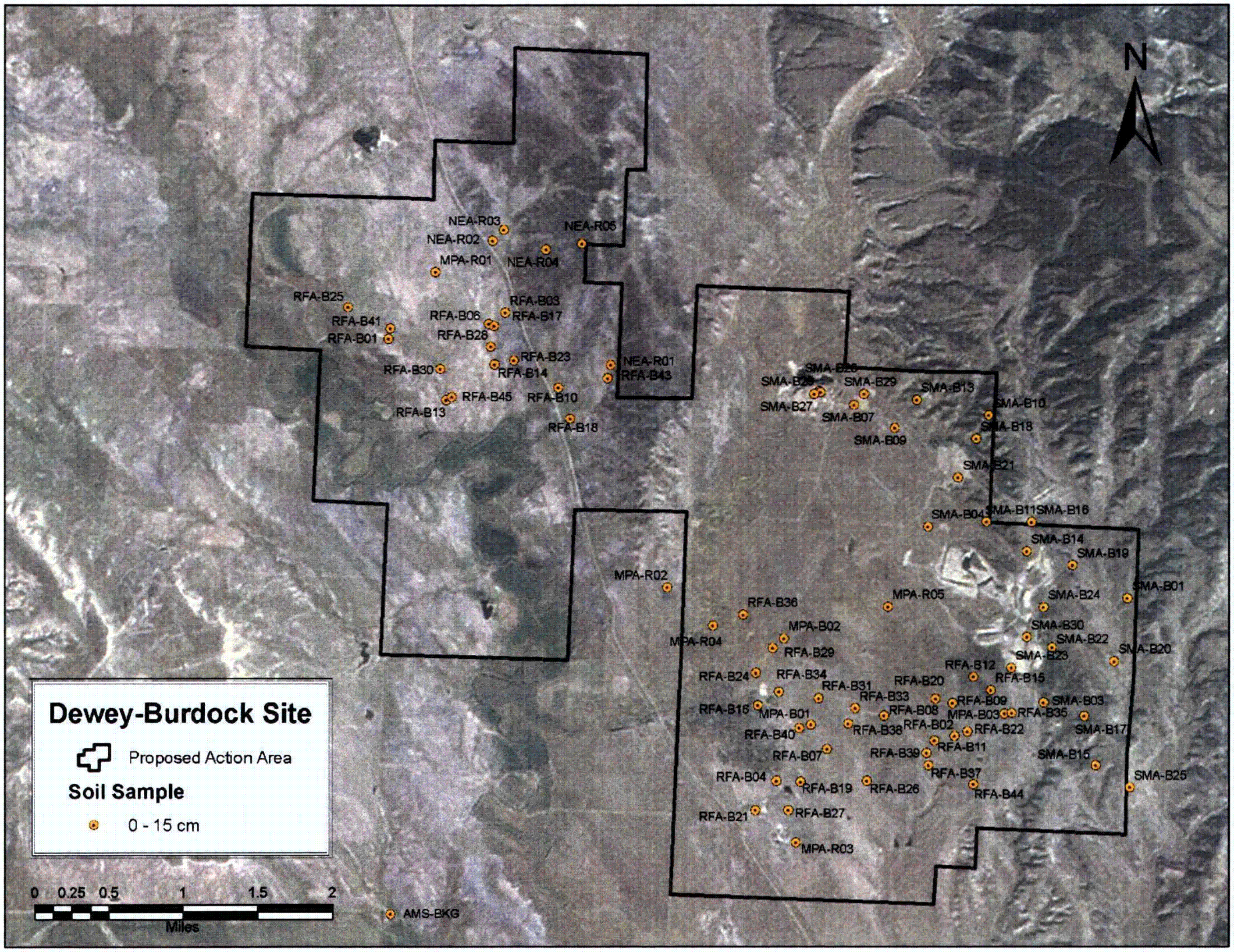


Figure 2.9-9: Surface Soil Sample Locations (80 Locations)

Land Application Areas

To characterize baseline radionuclide concentrations in soils in the land application areas, samples were collected at 17 locations, 10 in the northern and 7 in the southern area, from three intervals: 0 to 15, 15 to 30, and 30 to 100 cm. Refusal was encountered at 10 inches bgs in LAN-008 and the lower interval was not collected. The sample locations, selected randomly using VSP Version 5.0, are shown on Figure 2.9-10. The samples were analyzed for radium-226, natural uranium, thorium-230, and lead-210.

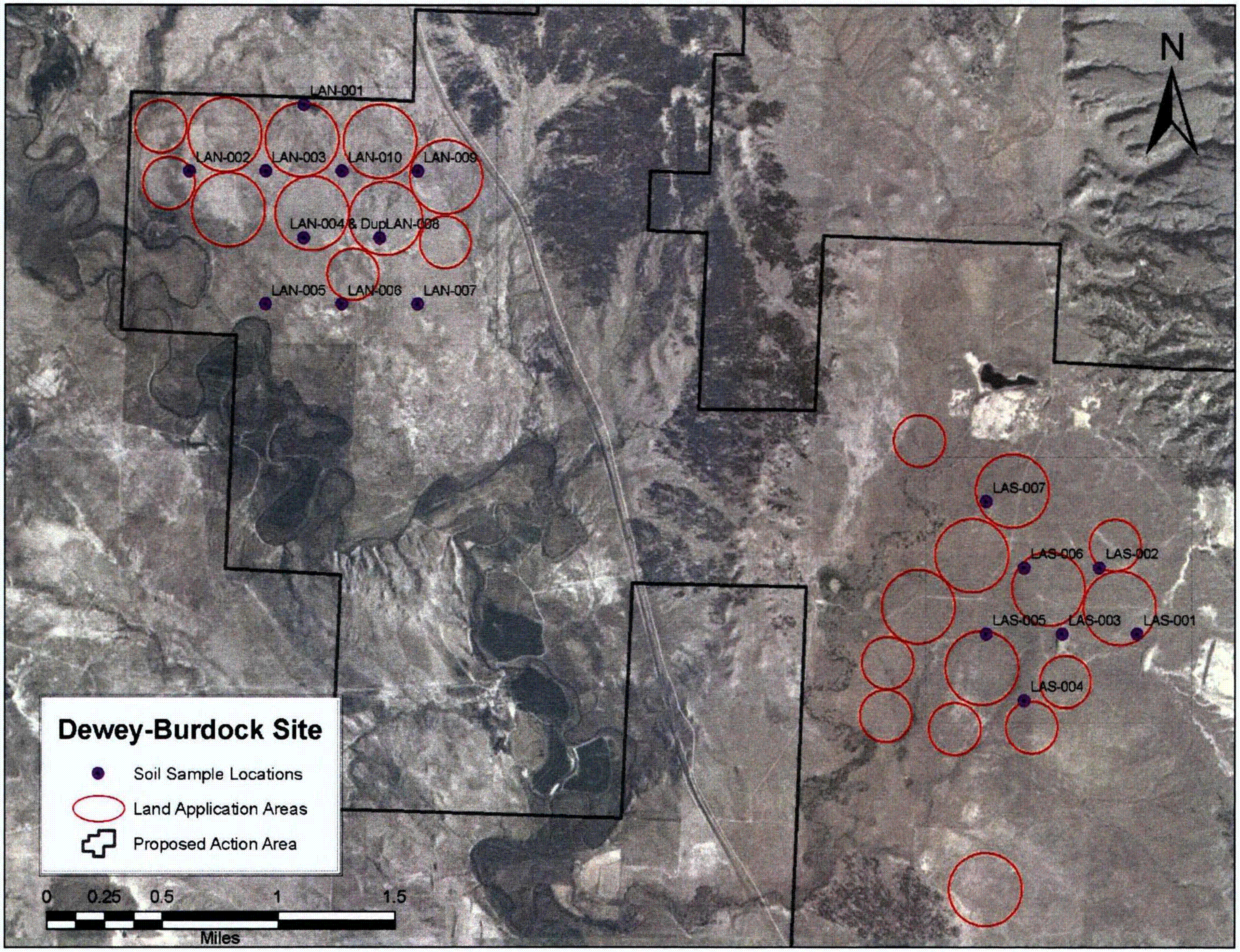


Figure 2.9-10: Soil Sample Locations in Land Application Areas

2.9.3.2 Soil Sampling Results

Table 2.9-5 presents the radium-226 concentrations in the soil samples collected in the main permit, surface mine, and land application areas. The results described in this section are those determined using only EPA Method 901.1. The laboratory analytical data reports are provided in Appendix B of Appendix 2.9-A.

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

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

POWERTECH (USA) INC.

Table 2.9-5: Radionuclide Concentrations in All Soil Samples

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

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

Sample ID	Date Collected	Depth (cm)	1-minute Gamma-Ray Count Rate (cpm)	U-nat (μCi/g)	Pb-210 (μCi/g)	Pb-210 Error (μCi/g)	Th-230 (μCi/g)	Th-230 Error (μCi/g)	Ra-226 (μCi/g)	Ra-226 Error (μCi/g)
RFA-B18	9/25/2007	0-15	13835	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B19	9/25/2007	0-15	13689	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B20	9/25/2007	0-15	13113	8.8E-07	1.0E-06	2.0E-07	5.0E-07	1.0E-07	1.3E-06	3.0E-07
RFA-B21A	9/26/2007	0-15	16641	-	-	-	-	-	5.6E-06	4.0E-07
RFA-B22	9/25/2007	0-15	14087	-	-	-	-	-	1.5E-06	2.0E-07
RFA-B23	9/25/2007	0-15	19674	-	-	-	-	-	3.6E-06	4.0E-07
RFA-B24	9/25/2007	0-15	12766	-	-	-	-	-	1.3E-06	2.0E-07
RFA-B25	9/25/2007	0-15	10300	6.7E-07	1.0E-06	2.0E-07	4.0E-07	1.0E-07	1.2E-06	2.0E-07
RFA-B26	9/25/2007	0-15	11791	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B27	9/25/2007	0-15	13794	-	-	-	-	-	1.5E-06	2.0E-07
RFA-B28	9/25/2007	0-15	15246	-	-	-	-	-	2.4E-06	3.0E-07
RFA-B28-Dup	9/25/2007	0-15	-	-	-	-	-	-	1.8E-06	3.0E-07
RFA-B29	9/25/2007	0-15	14345	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B30A	9/26/2007	0-15	12461	-	-	-	-	-	1.8E-06	2.0E-07
RFA-B31	9/25/2007	0-15	12221	-	-	-	-	-	1.3E-06	2.0E-07
RFA-B33	9/25/2007	0-15	13221	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B34	9/25/2007	0-15	13408	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B35	9/25/2007	0-15	12290	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B36A	9/25/2007	0-15	12465	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B37A	9/26/2007	0-15	11170	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B38	9/25/2007	0-15	11852	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B39	9/25/2007	0-15	11478	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B40	9/25/2007	0-15	12629	5.6E-07	1.0E-06	2.0E-07	3.0E-07	1.0E-07	1.1E-06	2.0E-07
RFA-B41	9/25/2007	0-15	11806	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B43	9/25/2007	0-15	13264	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B44	9/25/2007	0-15	11436	-	-	-	-	-	1.4E-06	2.0E-07
RFA-B45	9/25/2007	0-15	12242	-	-	-	-	-	1.6E-06	3.0E-07
SMA-B01	9/24/2007	0-15	10459	1.2E-06	6.0E-07	1.0E-07	5.0E-07	1.0E-07	9.0E-07	2.0E-07
SMA-B01-Dup	9/24/2007	0-15	-	1.5E-06	2.0E-06	2.0E-07	6.0E-07	1.0E-07	1.4E-06	3.0E-07
SMA-B03	9/24/2007	0-15	22410	-	-	-	-	-	1.5E-06	2.0E-07
SMA-B04	9/24/2007	0-15	15263	-	-	-	-	-	1.0E-06	2.0E-07
SMA-B07	9/24/2007	0-15	22925	-	-	-	-	-	3.2E-06	3.0E-07

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

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

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

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

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (concluded)

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

Notes:
All errors reported are ± 2σ.

2.9.3.2.1 Surface Soil Sampling Results

Radium-226 Concentrations in the First Set of 80 Locations

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

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

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

Radium-226 Concentrations in the Surface Mine Area

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

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

Radium-226 Concentrations in the Main Permit Area

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

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

Radium-226 Concentrations in the North Section of Main Permit Area

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

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

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

Radium-226 Concentrations in the Land Application Areas

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

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

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

Discussion of Radium-226 Concentrations

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

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

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

Other Radionuclides

Table 2.9-5 summarizes the analytical results for all samples analyzed for the extended suite of radiological parameters (all locations and depths combined). Although the sample number isn't sufficient to allow any definitive conclusions to be drawn regarding distributional characteristics or trends of non radium-226 parameters, a positive relationship between the concentrations of radium-226 and natural uranium, thorium-230, and lead-210 is apparent.

Limits of Detection

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

- The radium-226, lead-210, and thorium-230 LLDs (reported as MDCs or reporting limits) in the NEA, MPA, RFA, and SMA soil samples were all $1*10^{-7}$ µCi/g.
- The natural uranium LLDs in the NEA, MPA, RFA, and SMA samples ranged from $1.7*10^{-8}$ to $2.0*10^{-8}$ µCi/g.
- None of the results NEA, MPA, RFA, and SMA samples were below their respective LLDs.
- The lead-210 LLDs for the LAN and LAS samples ranged from $1.9*10^{-6}$ to $3.8*10^{-6}$ µCi/g. In all but one case, the lead-210 results were lower than their respective LLDs.
- The radium-226 LLDs for the LAN and LAS samples ranged from $4.0*10^{-8}$ to $1.0*10^{-7}$ µCi/g. All of the LAN and LAS results exceeded their respective LLDs.

- The thorium-230 LLD for the LAN and LAS samples was $1.0*10^{-7}$ μCi/g. Results for 17 of the 53 (surface and subsurface) samples were reported below $1.0*10^{-7}$ μCi/g.

- The natural uranium LLD for the LAN and LAS samples was $7.0*10^{-9}$ μCi/g. All of the results exceeded the LLD.

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

2.9.3.2.2 Subsurface Soil Sample Results

Table 2.9-5 lists the subset of subsurface biased samples that were collected at depth in the project roll front areas: RFA-B01, RFA-B02 RFA-B13 RFA-B15, RFA-B17, RFA-B21, RFA-B30, RFA-B36, and RFA-B37. The table also lists results obtained in subsurface samples collected in the two land application areas: LAN-001 through LAN-009 and LAS-001 through LAS-007.

2.9.3.2.3 Data Uncertainty

This section briefly summarizes the results of the quality control (QC) samples collected for the baseline soil sampling program. The results of this QC effort are documented in Table 2.9-6, which lists the errors and lower limits of detection (LLDs) for each duplicate pair. Table 2.9-6 documents associated comparisons, presenting the corresponding RPD (in the case of natural uranium) and/or Replicate Error Ratio (RER) for each QC pair. The calculation of RPDs and RERs is a standard technique used to evaluate laboratory precision.

The RPD is calculated as follows:

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

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

The RER is calculated as follows:

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

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

Table 2.9-6: Quality Control Analysis for Soil Samples

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

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

The consequences of one radium-226 and three lead-210 results exceeding the acceptance criteria are minimal since in each case the concentrations are low. In addition, lead-210 largely has no impact when addressing the impact of the baseline radiological characteristics of the site and potential impacts from site operations.

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

2.9.3.3 Conclusions

Main Project and Surface Mine Areas

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

Land Application Areas

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

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

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

2.9.4 Sediment Sampling

In June and August of 2008, baseline sediment sampling was conducted at the proposed project site in accordance with NRC Regulatory Guide 4.14 (NRC, 1980), which requires stream sediment samples during both seasonal runoff and low-flow conditions and one sediment sample at each impoundment to characterize radionuclide content. Stream sediment samples were collected at the same locations at which surface water quality sampling sites were located: upstream and downstream sites on Pass Creek, Beaver Creek, and the Cheyenne River, and one site on each of two ephemeral drainages located within the proposed project boundary. Impoundment sediment samples were collected in the same impoundments at which surface water chemistry was sampled. Figure 2.9-11 and Table 2.9-7 provide sediment sampling locations.

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

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

POWERTECH (USA) INC.

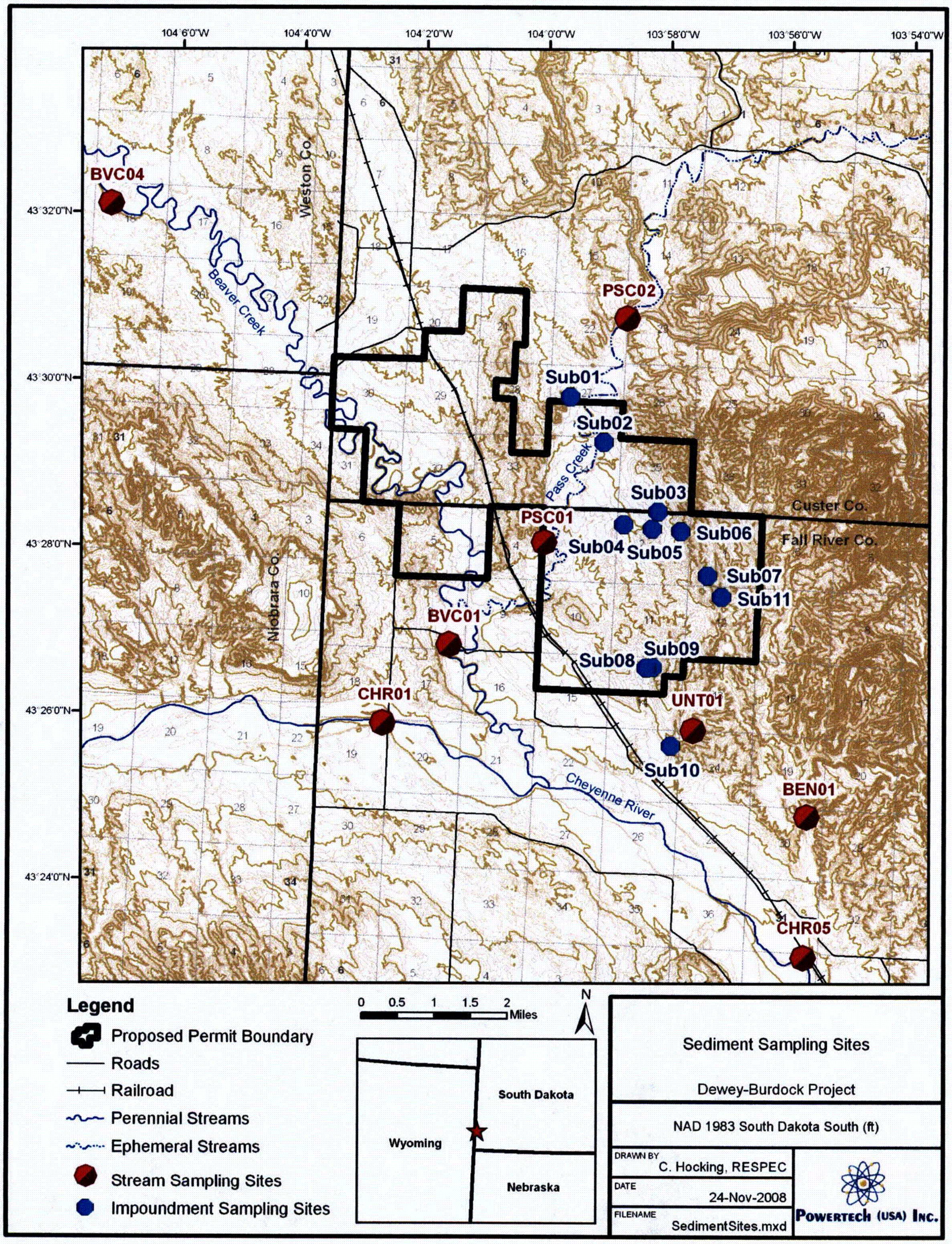


Figure 2.9-11: Sediment Sampling Sites

Table 2.9-7: Sampling Locations - Stream and Impoundment Sediment Sampling Locations

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

2.9.4.1 Methods

2.9.4.1.1 Stream Sediment Sampling

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

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

2.9.4.1.2 Surface Water Impoundment Sampling

Sediment sampling locations for surface water impoundments were the same as the subset of impoundments selected for water quality analysis. Impoundments were identified on aerial photographs and topographic maps and then field verified (Figure 2.9-12). A subset of 11 of the total 48 impoundments within a 2 km radius of the proposed permit boundary were chosen based on presence of water at commencement of water-quality sampling activities and their spatial distribution. The sampled impoundments include two open pit uranium mines and nine stock dams, one of which is fed by a free-flowing artesian Sundance well.

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

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

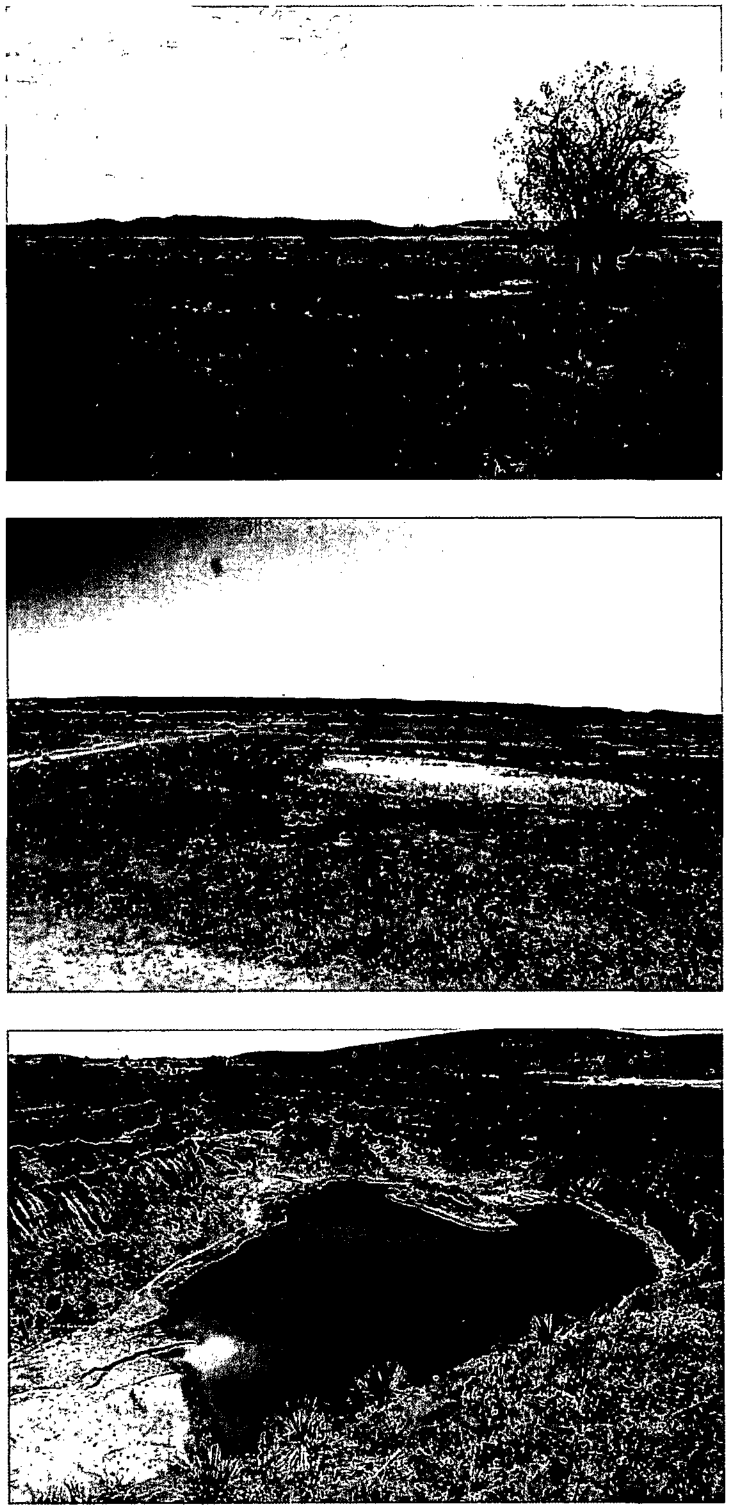


Figure 2.9-12: Surface Water Impoundments

2.9.4.2 Sediment Sampling Results

2.9.4.2.1 Stream Sediment Sample Results

Results of the stream sediment data for each stream channel sampling location and impoundment location are provided in Table 2.9-8. Beaver Creek sediment sample results from the historical TVA survey (TVA DES, 1980) are provided in Table 2.9-9.

Table 2.9-8: Radionuclide Concentrations in Stream Sediment Samples

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

Table 2.9-8: Radionuclide Concentrations in Stream Sediment Samples (concl.)									
		U-nat, Total	Ra-226, Total		Pb-210, Total			Th-230, Total	
		Result	Result	Precision	Result	Precision		Result	Precision
SiteID	Date	mg/kg-dry	pCi/g-dry	+/- pCi/g-dry	pCi/g-dry	+/- pCi/g-dry	Qualifier	pCi/g-dry	+/- pCi/g-dry
Sub05	6/18/2008	8.5	4.2	0.3	4.2	2.1		2.4	0.5
	8/21/2008	6.0	3.0	0.2	2.8	0.7		2.3	0.04
Sub06	6/23/2008	37	8.6	0.4	9.6	2.2		7.8	1.6
	8/21/2008	32	5.2	0.3	4.0	0.7		5.9	0.07
Sub07	6/23/2008	1.7	0.7	0.1	0.6	2	U	0.5	0.2
	8/21/2008	2.2	0.4	0.1	1.9	0.7		0.9	0.03
Sub08	6/23/2008	1.2	0.6	0.1	0.6	2.1	U	0.4	0.1
	8/21/2008	1.9	0.4	0.1	1.7	0.7		0.8	0.02
Sub09	6/23/2008	2.4	1.0	0.2	1.5	2	U	0.7	0.2
	8/21/2008	2.3	0.6	0.1	1.7	0.7		0.9	0.03
Sub10	6/23/2008	1.5	0.8	0.1	1.5	2.1	U	0.7	0.3
	8/21/2008	2.1	0.6	0.1	0.9	0.7	U	0.7	0.03
Sub11	6/23/2008	2.7	0.8	0.1	2.1	2.1	U	0.5	0.2
	8/21/2008	1.8	0.6	0.1	1.5	0.7		0.8	0.03

Table 2.9-9: Historical Radionuclide Concentrations in Beaver Creek Sediment Samples

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

Source: TVA DES, 1980

2.9.4.3 Conclusions

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

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

2.9.4.4 References

Myrick T.E. et al, "*Determination of Concentrations of Selected Radionuclides in the Surface Soil in the U.S*", Health Physics Vol 45, No 3 1983

U.S. Nuclear Regulatory Commission (NRC), 1980, Regulatory Guide 4.14, "*Radiological Effluent and Environmental Monitoring at Uranium Mills, Revision 1*", Nuclear Regulatory Commission Office of Standards Development, Washington, D.C.

2.9.5 Ambient Gamma and Radon Monitoring

2.9.5.1 Methods

2.9.5.1.1 Ambient Gamma Dose Rate Monitoring

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

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

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

2.9.5.1.2 Ambient Radon-222 Monitoring

Radtrak passive track etch detectors were placed at each of the eight AMS locations and an additional eight biased locations to measure radon-222 concentrations in air. For QC purposes, one duplicate detector was placed at each of two locations during each sampling event. The locations of the passive radon detectors are shown on Figure 2.9-8.

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

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

2.9.5.2 Results

2.9.5.2.1 Ambient Gamma Dose Rate Monitoring

The ambient gamma dose rate monitoring results are listed in Table 2.9-10. The results for the TLDs reported in millirem (mrem) ambient dose equivalents are as follows:

- AMS-01: 94.9 for 303 monitored days, projected to 114 mrem/yr
- AMS-02: 54.0 for 61 monitored days, projected to 323 mrem/yr
- AMS-03: 38.6 for 103 monitored days, projected to 137 mrem/yr
- AMS-04: 152.8 for 303 monitored days, projected to 184 mrem/yr
- AMS-05: 123.7 for 303 monitored days, projected to 149 mrem/yr
- AMS-06: 88.0, for 164 monitored days projected to 196 mrem/yr
- AMS-07: 145.3 for 303 monitored days, projected to 175 mrem/yr
- AMS-BKG: 167.8 for 303 monitored days, projected to 202 mrem/yr

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

Table 2.9-10: Ambient Gamma Dose Rates

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

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

2.9.5.2.2 Ambient Radon-222 Monitoring

The ambient radon monitoring results are listed in Table 2.9-11. Period 1 ambient radon concentrations ranged from 1.0 to 9.8, averaging 2.4 pCi/L. Period 2 concentrations ranged from 0.4 to 1.8, averaging 1.2 pCi/L. Period 3 concentrations ranged from 0.4 to 3.3, averaging 1.8 pCi/L. Period 4 concentrations ranged from 0.5 to 0.8, averaging 0.5 pCi/L.

Table 2.9-11: Radon Concentrations in Air

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

Table 2.9-11: Radon Concentrations in Air (cont'd)

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

Table 2.9-11: Radon Concentrations in Air (concl.)

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

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

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

Figure 2.9-13 presents the ambient radon concentrations in relation to the radium-226 concentrations predicted from the gamma-ray count rate data. One expects higher radon concentrations in the mined areas. However, there is only one case where this is true: the Q1 observation at Rn-02, located adjacent to the edge of an open pit mine, is 9.8 pCi/L. There appear to be no spatial trends in the current data set, other than the levels are within the same order of magnitude across the site, i.e., all less than 10 pCi/L and averaging 2.4, 1.2, 1.8, and 0.5 pCi/L in Periods 1 through 4, respectively.

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

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

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

POWERTECH (USA) INC.

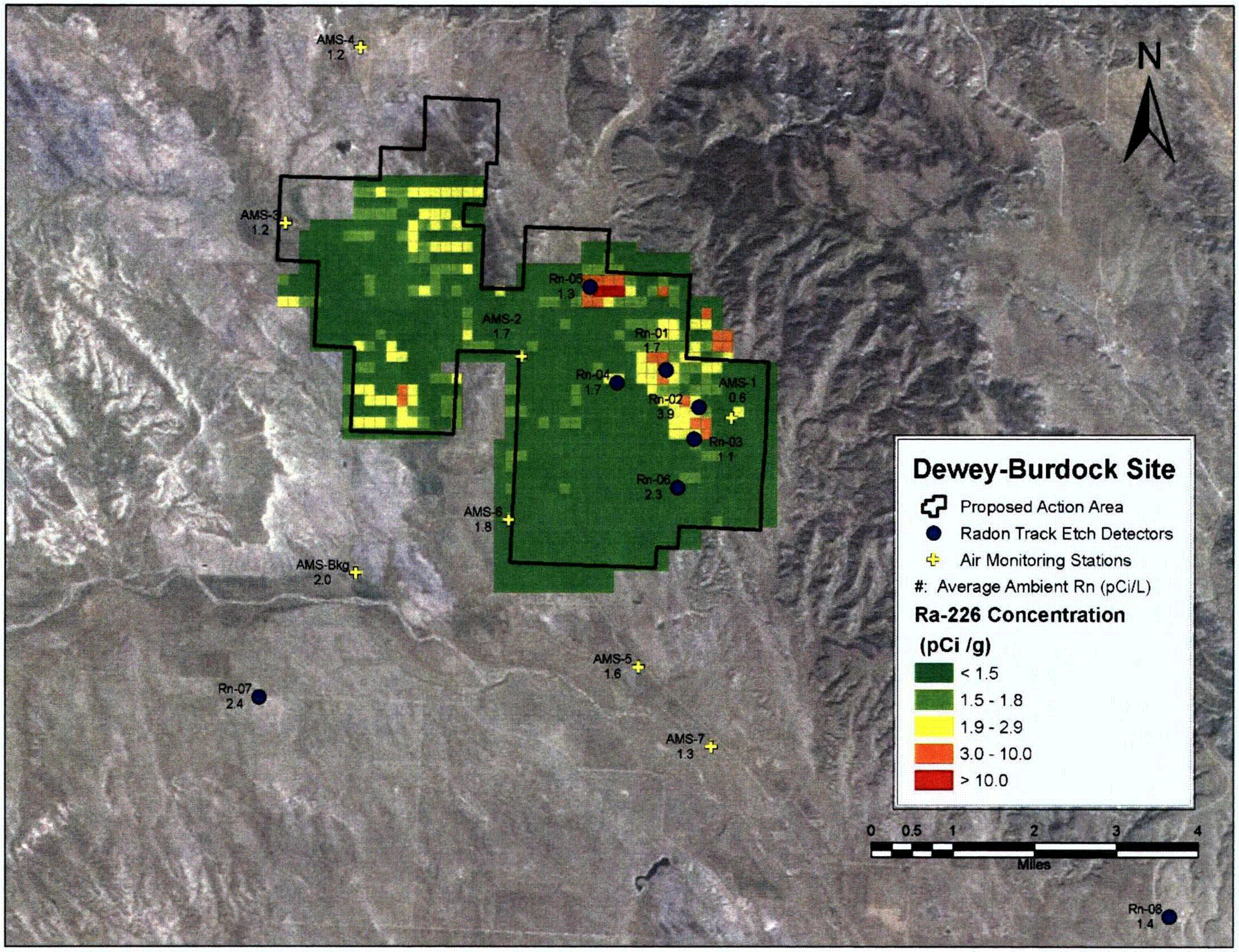


Figure 2.9-13: Radon Concentrations in Air in Relation to Predicted Radium-226 Concentrations

2.9.5.3 Conclusions

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

2.9.6 Air Particulate Monitoring

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

2.9.6.1 Methods

Eight Hi-Q Model HVP-4200AFC high volume air samplers were established within and surrounding the proposed permit area. The samplers operated nearly continuously from August 2007 to August 2008. The locations of the air samplers are shown on Figures 2.9-8 and 2.9-13.

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

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

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

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

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

The units of total flow and filter concentration in the equation are cubic meters and pCi/f, respectively. The resulting concentrations for each radionuclide and high volume sampler were compared to effluent concentration limits listed in Table 2 of 10 CFR 20 Appendix B and reported in Table 2.9-12 as percentages of the respective effluent limits. The most conservative effluent limits were applied to thorium-230 ($3*10^{-12}$ µCi/ml) and lead-210 ($6*10^{-13}$ µCi/ml). The Class D and W limits were applied to natural uranium ($3*10^{-12}$ µCi/ml) and radium-226 ($9*10^{-13}$ µCi/ml), respectively.

2.9.6.2 Air Particulate Sampling Results

In general and relative to one another (e.g., natural uranium to radium-226), the average concentrations of radionuclides were consistent at each location from period to period. The lowest average concentration was radium-226, followed by thorium-230, natural uranium, and lead-210. Average radium-226 concentrations were five orders of magnitude lower than lead-210 concentrations. The data are listed in Table 2.9-12 and summarized as averages and ranges in Table 2.9-13.

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

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

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

10^{-17} and 10^{-19} μCi/ml. Finally, lead-210 concentrations at each location were all on the order of 10^{-14} μCi/ml over the course of monitoring.

Table 2.9-12: Radionuclide Concentrations in Air

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

Table 2.9-12: Radionuclide Concentrations in Air (concl.)

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

Notes:

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

NR = Not reported by the laboratory.

Table 2.9-13: Summary of Radionuclide Concentrations in Air

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

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

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

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

The LLDs for each of the radionuclides are listed in Table 2.9-12.

2.9.6.3 Conclusions

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

2.9.7 Radon Flux Measurements

Radon flux rates were measured at nine locations on three occasions in the Dewey and Burdock roll front areas. The locations are shown on Figure 2.9-8. The locations coincide with the nine soil samples collected from 0 to 100 cm below ground surface (not in land application areas).

The first round of flux canisters was deployed on September 26, retrieved on September 27, and analyzed on September 28, 2007. The second round of flux canisters was deployed on April 20, retrieved on April 21, and analyzed on April 22, 2008. The third round of flux canisters was deployed on July 14, retrieved on July 15, and analyzed on July 16, 2008. The canisters were analyzed using U.S. Environmental Protection Agency (EPA) Test Method 115, Monitoring for Radon-222 Emissions. Results are documented in the Table 2.9-14. Sampling for the three periods yielded flux rates of 1.22, 0.74, and 1.5 picocuries per meter squared second (pCi/m^2-s), respectively. Flux rates ranged between 0.68 and 1.77 pCi/m^2-s in Fall 2007, 0.28 and 1.33 pCi/m^2-s in Spring 2008 and 0.48 and 2.38 pCi/m^2-s in Summer 2008.

Table 2.9-14: Baseline Radon Flux Measurements

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

2.9.7.1 Conclusions

The flux rates determined at the PAA are one to two orders of magnitude below the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) requirements of 20 pCi/m^2-s specified in 10 CFR 40, Appendix A, Criterion 6. Although the latter requirement applies to tailings and thus is not directly germane to this characterization, it is useful as a context to demonstrate the relatively low magnitude of baseline radon flux rates measured at the site.

2.9.8 Groundwater Sampling

At the project site, baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980). Because of the significant number of groundwater wells, their geochemical similarities, and an abundance of historical water quality data, a representative subset of the wells was selected for sampling. The wells were selected based on type of use, aquifer, and location in relation to the ore bodies. For the baseline study for the NRC permit, 19 groundwater wells (14 existing and 5 newly drilled) were selected as making up a representative sampling group for the area (Figure 2.7-19 and 2.7-20, Table 2.7-27). The wells selected for sampling include eight domestic wells, six stock watering wells, with three wells being hydrologically upgradient of the proposed production areas. The subset includes wells within the Fall River Formation (4), Lakota Formation (7), Inyan Kara Group (Fall River or Lakota) (2), Sundance Formation (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from July 2007 through June 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 12 wells were sampled monthly beginning in March 2008 and will continue to be sampled through February 2009 (Figure 2.7-20, Table 2.7-28). Of these 12 wells, six wells are in the Dewey area and six wells are near Burdock. At Dewey, there is a set of Fall River and Lakota wells sampled at three places, upgradient, within, and downgradient of proposed production activities. Near the Burdock area, the same well arrangement applies with two wells upgradient, within, and downgradient of proposed production areas. Data for radiological parameters available to date are presented in this section. As the monitoring program progresses, new data will be submitted to the NRC and EPA as they become available.

Comprehensive information on well locations and all water quality parameters is provided in sections of the project related specifically to groundwater (Section 2.7.2).

2.9.8.1 Methods

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

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

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

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

After measuring the pressure of capped free-flowing wells (where possible), the well valve was opened and the flow rate was allowed to stabilize, then flow measurements were made using a stopwatch and a marked container (usually a 5-gallon pail, but sometimes a 1-gallon container at slower-flowing wells). Casing purge time was calculated based on water column height, casing diameter, and flow rate. Three well volumes were required to have been purged before the well water was sampled. Additionally, a water-quality sonde with a flow-through cell was connected to the well and water quality parameters were periodically recorded. If parameters had not stabilized after purging 3 volumes, wells were allowed to continue to purge until parameters had stabilized, or until the purged volume was >> 3 well volumes.

Pumped wells were purged in such a manor as to induce flow from the formation into the well so that a sample of fresh formation water was collected.

- After measuring water level (where possible), the pump was started and flow rate was measured using stopwatch and 5-gallon marked pail.
- A water-quality probe equipped with a flow-through cell was connected to outflow.
- Wells with a high enough yield were purged for a minimum of three well volumes, and also until one or more indicator parameters had stabilized. Parameters monitored for stabilization were specific conductance, temperature, and pH. Field measurements were recorded periodically during purging of 3 volumes, and at least 3 minutes apart after purging 3 volumes. Table 2.9-15 gives requirements for parameter stabilization. After 3 well volumes had been purged and parameters stabilized, a sample was collected.
- Wells that had yields too low to be continuously pumped and purged of three well volumes were pumped dry and allowed to recover. After the well had sufficiently recovered, it was pumped and sampled. Accurate records of well purging are maintained to document the number of casing volumes purged from the well before sampling, but in all cases a minimum of one casing volume was purged before sampling.
- After calculating casing volume, alluvial wells were purged of 3 well volumes into a 5-gallon marked pail using either disposable bailers or a peristaltic pump. When using bailers, water quality parameters were recorded after each well volume was purged using a water-quality probe. When using the peristaltic pump, a water-quality probe equipped with flow-through cell was connected to pump outflow and parameters were recorded periodically during the purge.

Table 2.9-15: Stability Criteria for Collecting Ground Water Samples at Pumped Wells

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

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

Additional steps taken during water quality sampling include the following:

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

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

2.9.8.2 Groundwater Sampling Radiological Results

Results to date for dissolved radiological groundwater parameters are shown in Table 2.9-16 and Table 2.9-17.

POWERTECH (USA) INC.

Table 2.9-16: 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

POWERTECH (USA) INC.

Table 2.9-17: 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

2.9.8.3 Conclusions

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

2.9.9 Vegetation Sampling

Three rounds of vegetation sampling were conducted on the Dewey-Burdock Project. One vegetation sample was collected in August, 2007; and April and July, 2008 at each AMS, the locations of which are shown on Figures 2.9-8.

2.9.9.1 Methods

The samples were collected using grass clippers and placed in large plastic lawn bags, labeled appropriately, and stored in a laboratory supplied cooler until transferred to the laboratory. The analytes and corresponding analytical methods were the same as those used for soil. Polonium-210, determined using a laboratory-specific digestion and alpha spectrometry method, was added to the analytical suite (Energy Laboratories, 2008).

2.9.9.2 Vegetation Sampling Results

Table 2.9-18 presents the results of the vegetation sampling. There appear to be no temporal or spatial trends in the data. The following list is a summary of the averages for the set of samples:

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

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

Table 2.9-18: Baseline Radionuclide Concentrations in Vegetation

Location	Date Collected		8/14/2007	4/20/08	7/15/08	Average (µCi/kg)
AMS-01	U-nat (µCi/kg)	Concentration	1.4E-05	2.8E-02D	9.4E-06	1.4E-05
		Error ± 2σ	-	-	-	
		LLD	1.7E-06	2.4E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	5.5E-05	3.3E-05	8.1E-05	5.6E-05
		Error ± 2σ	3.2E-05	5.5E-06	1.2E-05	
		LLD	1.7E-06	3.7E-06	7.4E-06	
	Th-230 (µCi/kg)	Concentration	<1.7E-06	1.2E-05	1.2E-05	8.6E-06
		Error ± 2σ	<1.7E-06	5.2E-06	8.4E-06	
		LLD	1.7E-06	2.0E-07	8.4E-07	
	Pb-210 (µCi/kg)	Concentration	1.8E-03	2.9E-03	3.3E-04	1.7E-03
		Error ± 2σ	5.4E-04	1.1E-04	1.3E-04	
		LLD	8.6E-06	1.0E-06	2.1E-04	
	Po-210 (µCi/kg)	Concentration	1.3E-04	4.7E-04	1.7E-05	2.1E-04
		Error ± 2σ	9.8E-05	7.2E-05	1.5E-05	
		LLD	8.6E-06	1.0E-06	1.0E-06	
AMS-02	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	1.0E-05	2.7E-02D	3.2E-06	6.6E-06
		Error ± 2σ	-	-	-	
		LLD	5.5E-07	2.0E-07	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.2E-05	3.0E-05	9.3E-06	2.0E-05
		Error ± 2σ	1.1E-05	4.5E-06	3.6E-06	
		LLD	5.5E-07	2.8E-06	4.0E-06	
	Th-230 (µCi/kg)	Concentration	4.7E-06	1.4E-05	-9.5E-07U	5.9E-06
		Error ± 2σ	6.0E-06	4.9E-06	5.0E-06	
		LLD	5.5E-07	2.0E-07	4.7E-07	
	Pb-210 (µCi/kg)	Concentration	3.3E-04	1.3E-03	1.5E-04	5.9E-04
		Error ± 2σ	1.5E-04	6.9E-05	7.3E-05	
		LLD	2.7E-06	1.0E-06	1.2E-04	
	Po-210 (µCi/kg)	Concentration	1.8E-05	2.0E-04	9.1E-06U	7.6E-05
		Error ± 2σ	2.0E-05	4.2E-05	8.5E-06	
		LLD	2.7E-06	1.0E-06	1.0E-06	

Table 2.9-18: Baseline Radionuclide Concentrations in Vegetation (cont'd)

Location	Date Collected		8/14/2007	4/20/08	7/14/08	Average (µCi/kg)
AMS-03	U-nat (µCi/kg)	Concentration	9.8E-06	1.5E-01D	7.7E-06	9.8E-06
		Error ± 2σ	-	-	-	
		LLD	6.4E-07	2.4E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	7.4E-05	1.1E-04	7.5E-06	9.2E-05
		Error ± 2σ	2.2E-05	9.7E-06	4.9E-06	
		LLD	6.4E-07	3.7E-06	6.6E-06	
	Th-230 (µCi/kg)	Concentration	2.6E-06	4.1E-05	1.0E-05	2.2E-05
		Error ± 2σ	4.4E-06	1.1E-05	6.6E-06	
		LLD	6.4E-07	2.0E-07	7.7E-07	
	Pb-210 (µCi/kg)	Concentration	9.1E-04	1.4E-03	3.3E-04	8.8E-04
		Error ± 2σ	2.2E-04	8.2E-05	1.2E-04	
		LLD	3.2E-06	1.0E-06	1.9E-04	
	Po-210 (µCi/kg)	Concentration	7.8E-05	2.3E-04	9.6E-06U	1.5E-04
		Error ± 2σ	4.4E-05	4.4E-05	1.1E-05	
		LLD	3.2E-06	1.0E-06	1.0E-06	
AMS-04	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	9.3E-06	2.1E-02D	8.4E-06	9.3E-06
		Error ± 2σ	-	-	-	
		LLD	8.1E-07	1.9E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.3E-05	3.1E-05	9.3E-06	
		Error ± 2σ	1.4E-05	4.6E-06	5.2E-06	2.7E-05
		LLD	8.0E-07	2.8E-06	6.7E-06	
	Th-230 (µCi/kg)	Concentration	3.6E-06	8.3E-06	-2.7E-06U	6.0E-06
		Error ± 2σ	5.6E-06	4.2E-06	4.2E-06	
		LLD	8.0E-07	2.0E-07	7.7E-07	
	Pb-210 (µCi/kg)	Concentration	1.5E-03	1.2E-03	2.1E-04	1.4E-03
		Error ± 2σ	3.0E-04	6.6E-05	1.2E-04	
		LLD	4.0E-06	1.0E-06	1.9E-04	
	Po-210 (µCi/kg)	Concentration	9.8E-05	1.7E-04	9.0E-06U	
		Error ± 2σ	6.4E-05	3.9E-05	9.6E-06	1.3E-04
		LLD	4.0E-06	1.0E-06	1.0E-06	

Table 2.9-18: Baseline Radionuclide Concentrations in Vegetation (cont'd)

Location	Date Collected		8/14/2007	4/20/08	7/14/08	Average (µCi/kg)
AMS-05	U-nat (µCi/kg)	Concentration	3.7E-05	2.3E-01D	1.4E-05	3.7E-05
		Error ± 2σ	-	-		
		LLD	1.3E-06	1.3E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.4E-05	7.9E-05	5.9E-06U	5.2E-05
		Error ± 2σ	1.8E-05	5.7E-06	5.3E-06	
		LLD	1.3E-06	1.8E-06	7.7E-06	
	Th-230 (µCi/kg)	Concentration	1.5E-05	4.8E-05	-8.8E-07U	3.2E-05
		Error ± 2σ	1.7E-05	8.1E-06	5.7E-06	
		LLD	1.3E-06	2.0E-07	8.8E-07	
	Pb-210 (µCi/kg)	Concentration	1.7E-03	3.3E-04	3.4E-04	1.0E-03
		Error ± 2σ	4.2E-04	3.0E-05	1.4E-04	
		LLD	6.5E-06	1.0E-06	2.2E-04	
	Po-210 (µCi/kg)	Concentration	6.6E-05	1.6E-04	2.1E-05	1.1E-04
		Error ± 2σ	6.0E-05	3.1E-05	1.6E-05	
		LLD	6.5E-06	1.0E-06	1.0E-06	
AMS-06	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	3.8E-05	1.3E-01D	2.2E-05	3.8E-05
		Error ± 2σ	-	-		
		LLD	8.3E-07	3.2E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	3.2E-05	9.2E-05	1.8E-05	6.2E-05
		Error ± 2σ	1.6E-05	9.9E-06	5.0E-06	
		LLD	8.2E-07	4.6E-06	5.0E-06	
	Th-230 (µCi/kg)	Concentration	1.9E-05	3.9E-05	2.1E-05	2.9E-05
		Error ± 2σ	1.3E-05	1.1E-05	7.4E-06	
		LLD	8.2E-07	2.0E-07	5.7E-07	
	Pb-210 (µCi/kg)	Concentration	1.0E-03	1.8E-03	1.4E-04U	1.4E-03
		Error ± 2σ	2.6E-04	1.1E-04	8.7E-05	
		LLD	4.1E-06	1.0E-06	1.4E-04	
	Po-210 (µCi/kg)	Concentration	6.0E-05	4.0E-04	5.7E-06U	2.3E-04
		Error ± 2σ	4.4E-05	7.7E-05	5.7E-06	
		LLD	4.1E-06	1.0E-06	1.0E-06	

Table 2.9-18: Baseline Radionuclide Concentrations in Vegetation (concl.)

Location	Date Collected		8/14/2007	4/20/08	7/14/08	Average (µCi/kg)
AMS-07	U-nat (µCi/kg)	Concentration	1.8E-05	1.4E-01 D	2.7E-05	1.8E-05
		Error ± 2σ	-	-		
		LLD	9.7E-07	21E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.7E-05	7.6E-05	2.4E-05	5.2E-05
		Error ± 2σ	1.6E-05	7.2E-06	7.5E-06	
		LLD	9.7E-07	3.0E-06	7.7E-06	
	Th-230 (µCi/kg)	Concentration	1.6E-05	4.0E-05	2.0E-05	2.8E-05
		Error ± 2σ	1.8E-05	1.2E-05	8.6E-06	
		LLD	9.7E-07	2.0E-07	8.6E-07	
	Pb-210 (µCi/kg)	Concentration	2.1E-03	6.2E-04	-3.2E-05U	1.4E-03
		Error ± 2σ	3.6E-04	5.3E-05	1.3E-04	
		LLD	4.8E-06	1.0E-06	2.1E-04	
	Po-210 (µCi/kg)	Concentration	1.5E-04	2.3E-04	2.0E-05	1.9E-04
		Error ± 2σ	8.2E-05	4.7E-05	1.3E-05	
		LLD	4.8E-06	1.0E-06	1.0E-06	
AMS-BKG	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	4.0E-05	9.0E-02D	1.0E-05	2.5E-05
		Error ± 2σ	-	-	-	
		LLD	9.7E-07	3.8E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	4.1E-05	8.3E-05	1.3E-05	6.2E-05
		Error ± 2σ	2.0E-05	1.1E-05	4.6E-06	
		LLD	9.7E-07	6.4E-06	5.1E-06	
	Th-230 (µCi/kg)	Concentration	1.0E-05	3.5E-05	7.3E-06	2.3E-05
		Error ± 2σ	1.3E-05	1.2E-05	4.2E-06	
		LLD	9.7E-07	2.0E-07	5.6E-07	
	Pb-210 (µCi/kg)	Concentration	6.9E-04	1.4E-03	1.3E-04U	1.0E-03
		Error ± 2σ	2.8E-04	1.0E-04	8.6E-05	
		LLD	4.8E-06	1.0E-06		
	Po-210 (µCi/kg)	Concentration	2.5E-05	2.2E-04	9.3E-06	1.2E-04
		Error ± 2σ	3.2E-05	5.1E-05	8.8E-06	
		LLD	4.8E-06	1.0E-06	1.0E-06	

Notes:
D = Lower limit of detection increased due to sample matrix interference. Average concentrations s do not include "D"-qualified results.

2.9.9.3 Conclusions

Other than the observation that radionuclide concentrations in the vegetation samples are one to two orders of magnitude lower than those in the corresponding shallow (0 to 5 cm) soil samples, there are no apparent relationships between the media. Radium-226, natural uranium, and thorium-230 concentrations were highest in offsite soil sample AMS-BKG, located 1.9 miles west of the site near the offsite topsoil pile. Only the concentration of natural uranium was highest at this location in vegetation and soil. The concentration of radium-226 in soil at this location was in the middle of its range.

2.9.10 Food Sampling

To determine baseline radionuclide concentrations in local food, Powertech (USA) collected three tissue samples, one liver (DBAT 03) and two meat samples (DBAT 01 DBAT 02), from a locally grazing cow on June 25, 2008. The results are listed in Table 2.9-19. Errors are reported as $\pm 2\sigma$.

Table 2.9-19: Baseline Radionuclide Concentrations in Local Food

Sample ID	Radionuclide	Parameter	Result
DBAT-01	**U-nat (µCi/kg)**	**Concentration**	ND
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	3.0E-06
		Error ± 2σ	2.0E-06
		LLD	3.0E-06
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	2.0E-05
		LLD	8.0E-06
	Pb-210 (µCi/kg)	Concentration	-7.0E-06
		Error ± 2σ	4.0E-05
		LLD	7.0E-06
	Po-210 (µCi/kg)	Concentration	8.0E-06
		Error ± 2σ	1.0E-04
		LLD	8.0E-06
DBAT-02	**U-nat (µCi/kg)**	Concentration	ND
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	6.0E-05
		Error ± 2σ	3.0E-05
		LLD	4.0E-05
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.4E-03
		LLD	1.0E-04
	Pb-210 (µCi/kg)	Concentration	2.0E-04
		Error ± 2σ	7.0E-04
		LLD	1.2E-03
	Po-210 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.2E-03
		LLD	1.0E-04
DBAT-03	**U-nat (µCi/kg)**	Concentration	ND
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	3.0E-06
		Error ± 2σ	1.0E-06
		LLD	2.0E-06
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.0E-04
		LLD	6.0E-06
	Pb-210 (µCi/kg)	Concentration	-7.0E-06
		Error ± 2σ	4.0E-05
		LLD	6.0E-05
	Po-210 (µCi/kg)	Concentration	2.0E-05
		Error ± 2σ	2.0E-04
		LLD	6.0E-06

There are several cases where reported concentrations are at or below LLDs that, in turn, exceed the LLDs recommended in RG 4.14. This is evident for all reported concentrations of natural uranium, radium-226 and polonium-210 in Sample DBAT-01, and lead-210 in all three samples.