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 and a pig, direct radiation, radon-222 in air; and radon-222 flux rates representative of the project property. The work was performed by Environmental Restoration Group (ERG) between August 2007 and July 2008, with additional food sampling in April 2011.

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

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

The baseline radiological field investigation consisted of the following activities:

- A GPS-based gamma survey conducted at 100 to 500 m transects spanning the 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 samples of locally grazed livestock including beef and a pig.

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

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

Table 2.9-1: Summary of Baseline Radiological Investigation Scope

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

2.9.1.1 References

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

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

Survey Methodology

A GPS-based gamma survey was conducted over the main and surface mine areas of the project in September 2007 and July 2008. The initial GPS-based gamma survey was performed in the Main Permit Area and Surface Mine Area using 500-meter and 100-meter transect spacing, respectively, from September 13-27, 2007. The boundary of the Main Permit Area was later extended to the southwest. Refer to Figure 2.9-6 for the locations of the Main Permit Area and Surface Mine Area. The 500-meter survey lines were extended south to this new boundary by mobilizing to the site and conducting the survey on July 14, 2008. Work continued from July 17-19, 2008, where additional data within the Land Application Areas were obtained to comply with the desire to have data on 100-meter transect spacing therein. Transects at a spacing of 100 meters were added within the previously determined 500-meter transects within the Land Application Areas only. Land Application Areas are depicted on Figure 3.1-1. Figures 2.9-3 and 2.9-4 indicate the locations of the gamma-ray surveys.

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

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

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

Combining Data from Two Surveys

The use of a correlation to predict the Ra-226 in soil requires that all data, including the gamma survey and correlation data, be collected under similar soil moisture conditions. All data were gathered in fair weather during the late summers of 2007 and 2008 under similar soil moisture conditions. No effect on the gamma ray count rate-soil Ra-266 correlation is expected nor was one observed.

Another consideration when combining data from two surveys is whether the data from 2007 and 2008 may be combined because of possible different background count rates. A search for overlapping 2007/2008 areas was completed, concentrating on overlap areas considered free of anomalies. Ten areas of overlapping data (within 3 feet) were identified and corresponding count rates were recorded and compared, as shown in Table 2.9-1a. The results confirm that the survey instruments produced count rates that were similar, with a mean ratio of the two count rates of 1.01 and a maximum difference of any two data points of 15 percent. An Anderson-Darling test was done to see if the differences of the paired data were of a normal distribution. The results of the Anderson-Darling test for normality yielded a p-value of 0.093 (cannot reject normal distribution hypothesis). Then a paired t-test was performed to determine whether the differences were significantly different from 0. The results of the paired t-test were a p-value of

Table 2.9-1a: Data Pairs from 2007 and 2008 Gamma Surveys

Location	2007 Count Rate (cpm)	2008 Count Rate (cpm)	Ratio 2007:2008
1	12,721	14,985	0.85
2	12,060	11,309	1.07
3	12,186	11,299	1.08
4	11,958	11,562	1.03
5	15,016	15,074	1.00
6	13,358	13,752	0.97
7	13,829	13,970	0.99
8	12,685	12,207	1.04
9	15,788	14,633	1.08
10	12,979	12,945	1.00
		Mean	1.01

0.787 (cannot reject zero-difference hypothesis), an average difference of 84 cpm, and a 95% confidence interval on the average difference of (-603 cpm, 772 cpm). In summary, the two data sets are not statistically different from one another and combining the data sets has no impact on the statistics when summarizing the gamma count rate in and around the project area.

A significant effort was made to match the instrument responses to background radiation and radiation sources prior to deployment for the 2007 survey. In preparing for the 2008 survey, the instrument performances were again matched to one another and to the performances of the instruments used in 2007. Since the instrument responses in background areas were the same for the 2007 and 2008 surveys, Powertech (USA) concludes that the background radiation was very similar for the two surveys and that merging the data was appropriate.

A statistical evaluation of the total data set and sets of data corresponding to defined areas is presented in the Baseline Radiological Report (Appendix 2.9-A), including tests for normality and log transforms. All frequency distributions were found to be nonparametric, and conventional approaches were used to describe these distributions. Powertech (USA) does not believe that a test of variance of the three defined areas would add meaningful information to the discussion regarding the Main Permit Area, the anomalous north area, and the Surface Mine Area since the anomalous north area and the Surface Mine Area are clearly different from the remainder of the Main Permit Area based on historical use and geological features.

Technical Justification for Transect Spacing

Regulatory Guide 4.14 recommends a total of 80 direct radiation measurements at 150 m (492 ft) intervals up to a distance of 1,500 m (4,921 ft) in eight directions from the center or 5 or more

direct radiation measurements at the locations used for collection of particulate samples once prior to site construction. As an alternative to the Regulatory Guide 4.14 guidance, Powertech (USA) co-located TLDs with the air particulate samplers and collected additional direct radiation measurements (gamma-ray surveys) using ATVs as discussed below. The number of direct gamma measurements collected by Powertech (USA) (157,057) greatly exceeds the number recommended in Regulatory Guide 4.14 (80).

The gamma transect spacing was intentionally small when surveying suspected radiologically anomalous areas. A larger spacing (500 m) was used for areas not anticipated to be impacted by naturally occurring radioactive materials (NORM), and a smaller spacing (100 m) was used for known or potential NORM impacted areas. While this work was done prior to recently published data by Whicker, et al. (2008), Powertech (USA) believes that the methods are similar to and consistent with that publication. Whicker et al. did not recommend transect spacing. They reported typical transect spacing that they used for certain situations (including surveys for cleanup). Powertech (USA) does not believe that the authors intended to establish a standard method. The measure of success for the gamma survey is determined by asking the questions: did the survey adequately determine the mean and variance of the exposure rates for areas within the site, and did it identify areas with highly varying exposure rates commonly referred to as anomalous areas? Powertech (USA) believes that the answer to both questions is yes.

The technical justification for the 500-meter transect spacing is based on the assumption that mineralized ore outcrops were not anticipated in areas where this transect spacing was used. Therefore, non-impacted areas were expected to be made up of large areas of different soil types or large fields having a unique history of fertilizer applications, if any. The characteristic sizes of these areas were expected to be large compared to 500 meters.

Data from the surveys were evaluated at the end of each day to determine whether the gamma count rates were consistent with the assumptions. Data anomalies were investigated and, where appropriate, the transect spacing and areal extent of the survey were changed to bound the anomaly. During the survey, an exposure-rate anomaly near a flowing artesian well was discovered and additional measurements were made to delineate the area. The data also showed that a region at the north end of the site had a slightly higher average exposure rate. However, an evaluation in the field indicated that the variance was not high and that this anomalous region was due to different geology. Also the gamma survey boundary was extended in the Surface Mine Area so that an anomaly on the original survey boundary could be bounded. These daily evaluations of the data and changes to the survey density were made to correct for small departures from the conditions that were assumed when developing the plans.

Considering Variations in Background Count Rates during Cleanup Operations

10 CFR Part 40, Appendix A, Criterion 6(6) decommissioning regulations limit the radionuclide concentrations in soil. Compliance with the cleanup criteria is based on laboratory analysis of soil samples. While it is true that gamma-ray action levels are used to identify anomalies, the accuracy of the action levels is known to be limited, due to changes in background count rates, vertical distribution and aerial extent of radionuclides, soil moisture, and other factors. Experience has shown that results of gamma surveys cannot be reliably interpreted if done when there is excessive soil moisture. This limitation in itself reduces the variation in background count rates during cleanup operations. Action levels are conservatively set and periodically revaluated during cleanup, especially when known changes may influence gamma-ray emissions. The confidence lines of correlations such as in those shown in Figures 5-1 and 5-2 in Appendix 2.9-A are useful in establishing conservative gamma-ray action levels. Normally the application of these conservatively chosen action levels results in cleanup to near background levels, in accordance with NRC's ALARA policy.

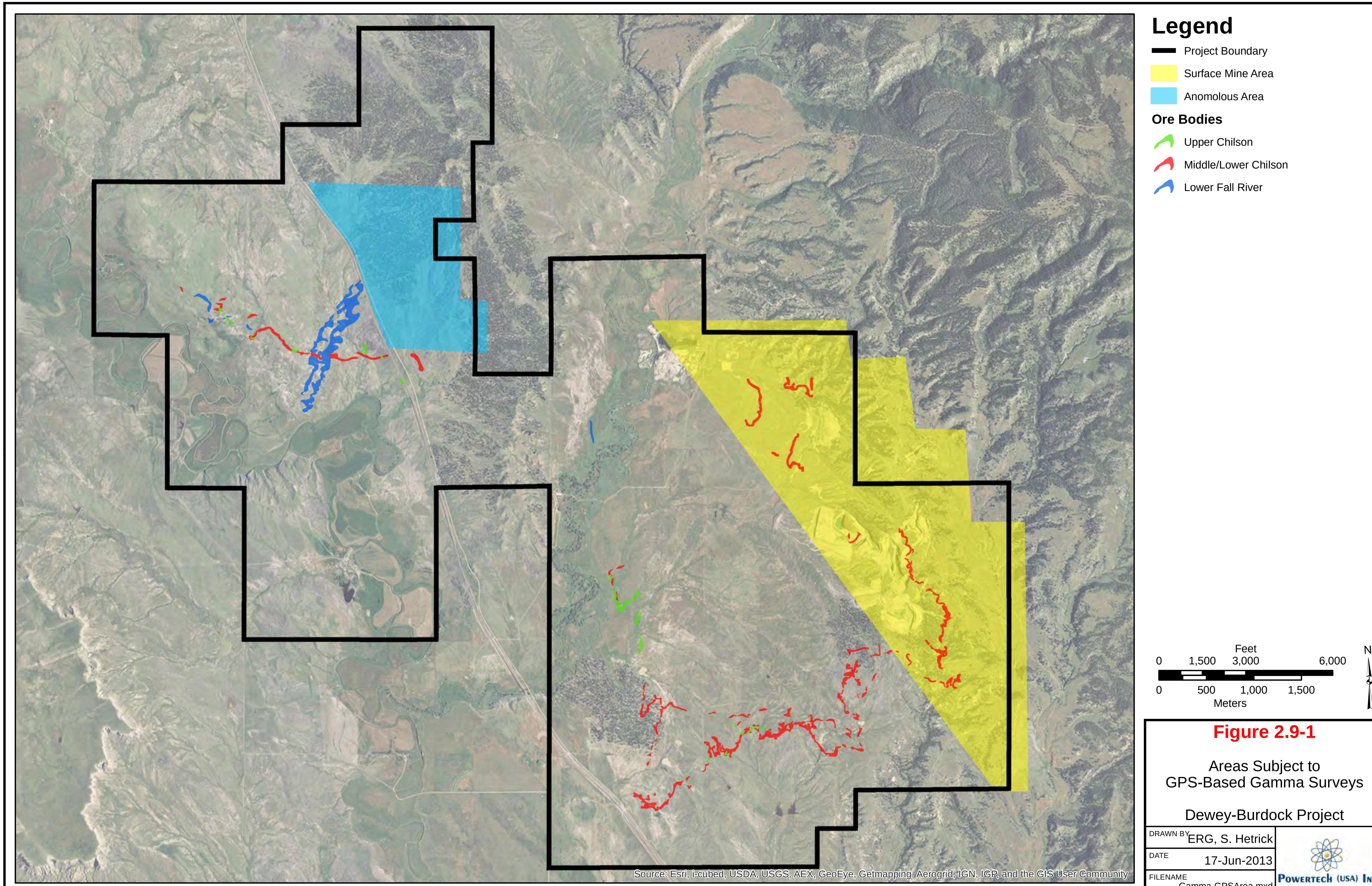

Figure 2.9-1

Areas Subject to GPS-Based Gamma Surveys

Dewey-Burdock Project

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.

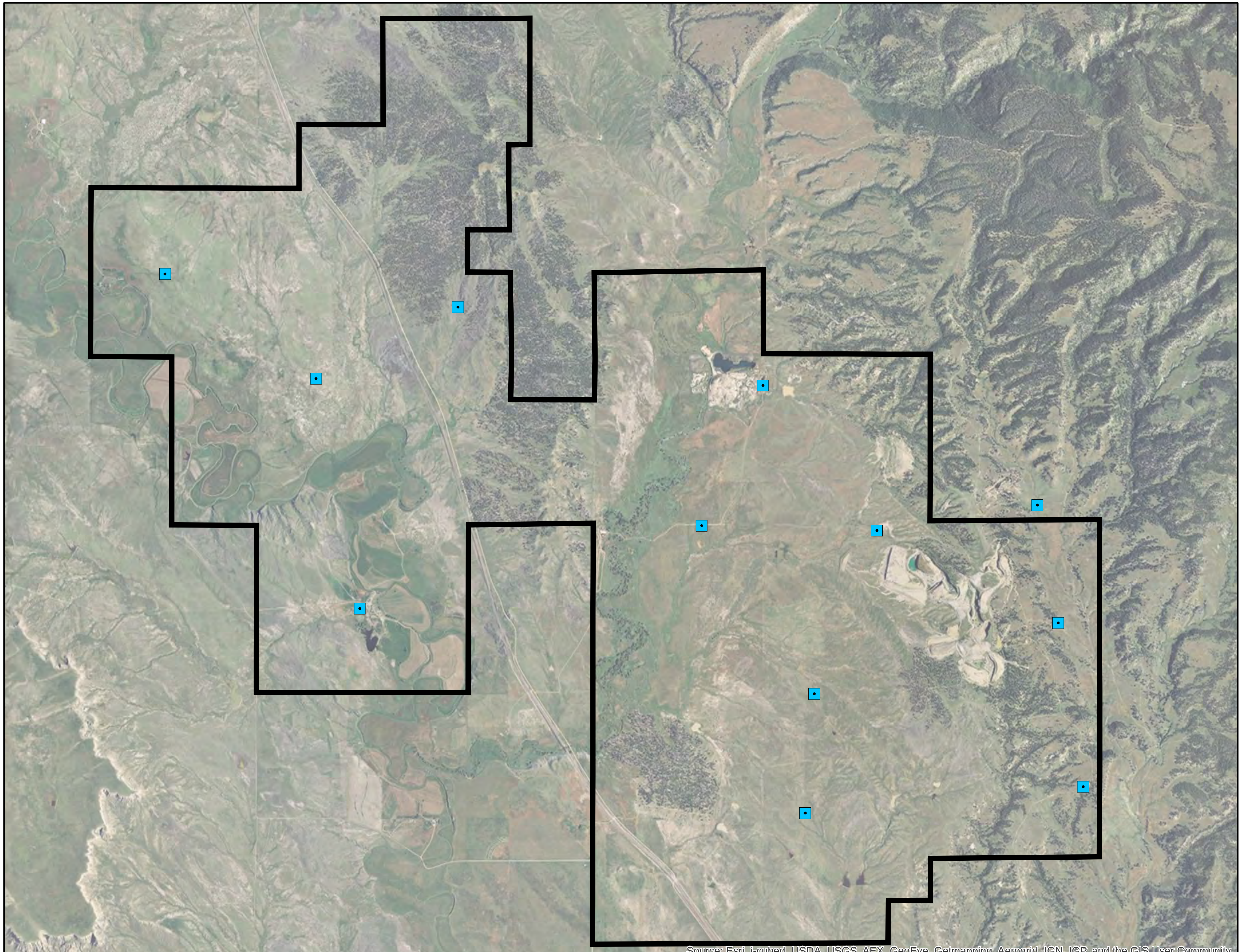

Figure 2.9-2

Locations of High Pressure Ion Chamber and Sodium Iodide Detector Measurements Dewey-Burdock Project

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2.9.2.1.3 Gamma/Radium-226 Correlation

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

The correlation was used to translate each of the gamma-ray count rates obtained in the GPS-based survey to predicted radium-226 concentrations. ArcView GIS was used to map the predicted site-wide radium-226 concentrations. The input parameters to ArcView GIS were gross gamma-ray count rates, in counts per minute (cpm), measured using matched sodium iodide detectors and recorded during the GPS-based survey. The results obtained from ArcView GIS were the predicted Ra-226 concentrations, in pCi/g, calculated using Equation 2.2 given in Section 2.9.2.2.3:

$$Ra\text{-}226\ Concentration = 1.9 * 10^{-4}\ x\ Gamma\text{-}Ray\ Count\ Rate - 1.04$$

2.9.2.1.4 Data Quality Assurances/Quality Control

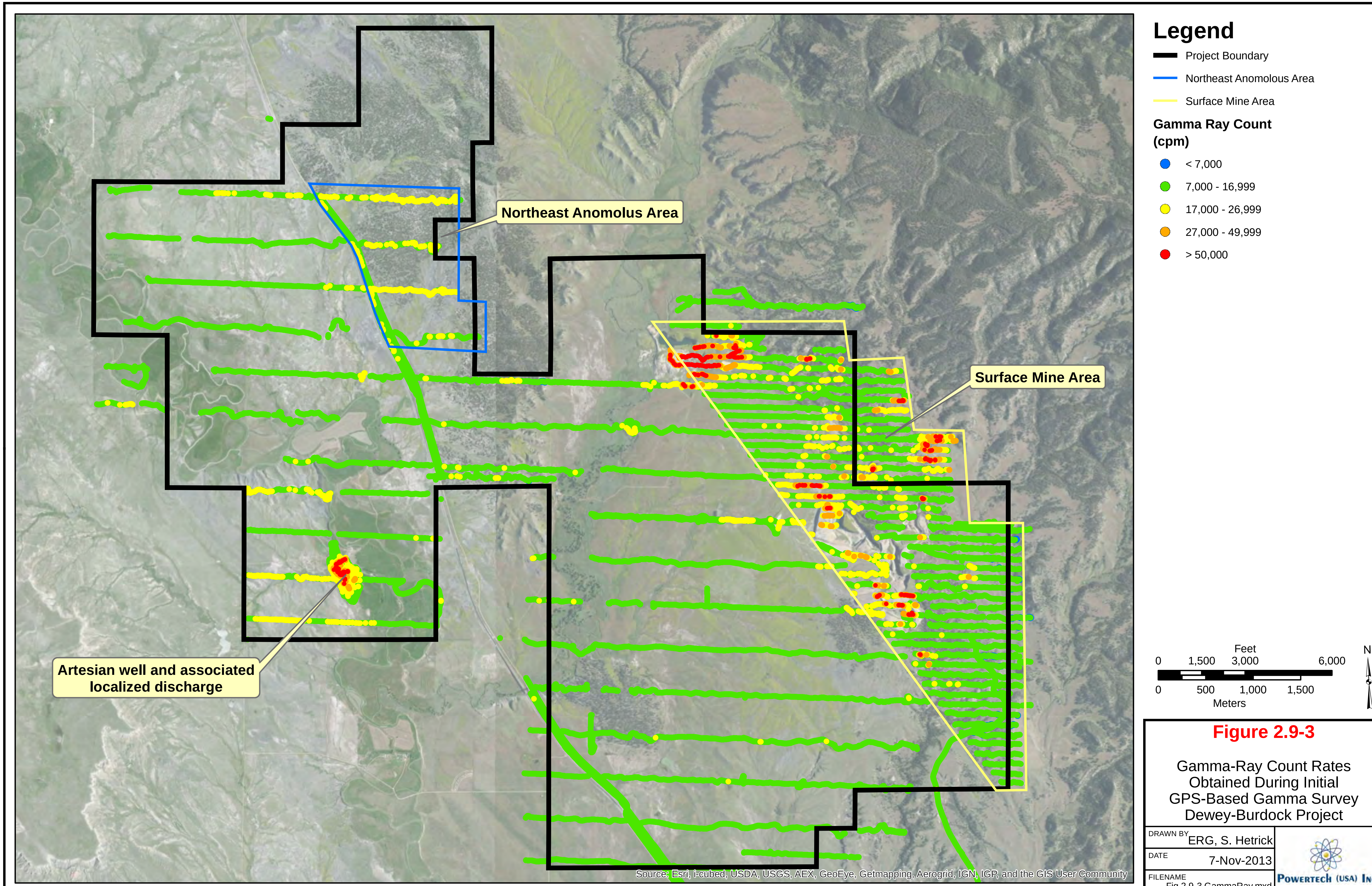
All survey instruments were calibrated. The function of survey instruments was checked at the beginning and end of each work day using a National Institute of Standards and Technology-traceable cesium-137 source. Calibration Sheets and function check data are provided in Appendix A of Appendix 2.9-A. Appendix 2.9-A includes a description of the criteria (including the basis for the criteria) used to evaluate the acceptability of the daily function tests.

2.9.2.2 Gamma Survey Results

2.9.2.2.1 Baseline Gamma Survey Results

The gamma-ray count rate data obtained in the initial survey were first evaluated as an entire set and then subdivided into the main permit (the entire data set less the surface mine area) and surface mine areas. The gamma data from the Main Permit Area, Surface Mine Area, and both land application areas (Dewey and Burdock) were analyzed separately with the statistical software package Minitab, version 15.1.1.0. Output graphs from Minitab are provided in Appendix 2.9-L.

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.


Legend
Project Boundary
Northeast Anomolous Area
Surface Mine Area
Gamma Ray Count (cpm)
< 7,000
7,000 - 16,999
17,000 - 26,999
27,000 - 49,999
> 50,000
Northeast Anomolus Area
Surface Mine Area
Artesian well and associated localized discharge
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500
Meters
N
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Figure 2.9-3
Gamma-Ray Count Rates Obtained During Initial GPS-Based Gamma Survey Dewey-Burdock Project
DRAWN BY ERG, S. Hetrick
DATE 7-Nov-2013
FILENAME Fig 2.9-3 GammaRay.mxd
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None of the data sets: the entire permit area, and gamma data obtained in the main permit and surface mine areas are normally, lognormal, or exponentially distributed. Furthermore, normalizing data transformations were conducted and the transformed data did not follow standard distributions. For these reasons, data analysis and summaries were performed using non-parametric statistical methods, which are less sensitive to extreme observations typical of skewed data distributions.

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

Several tools were used to identify potential outliers, including histograms, distribution tests, and probability plots. Support for the use of box plots and IQRs to screen outliers is found in Chapter 12 of *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (EPA, 2009). In any case, it is important to clarify that potential outliers were identified for informational purposes (e.g., to determine whether the data sets could be described by various distributions without the potential outliers included). The potential outliers defined using the IQR method were not removed or discounted in the statistical analysis of the GPS gamma data.

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

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

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

Notes:

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

Main Project Area

As shown in Table 2.9-2, the median gamma-ray count rate for the main project area data set was 12,664 cpm for 75,345 observations. The count rates ranged from 5,883 to 171,243 cpm. Low outliers in the main project area data set, count rates below 7,790 cpm, appear to be limited to two clusters. High outliers in the data set, count rates exceeding 17,946 cpm, appear to be limited to an approximately 600-acre located at the north end of the main project area. The area is identified as an anomalous area on Figure 2.9-1.

Approximately 0.2 and 3 percent of the gamma-ray count rates observed in the main project area are comprised of low and high outliers, respectively.

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

Surface Mine Area

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

Discussion

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

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

Land Application Areas

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

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

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

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

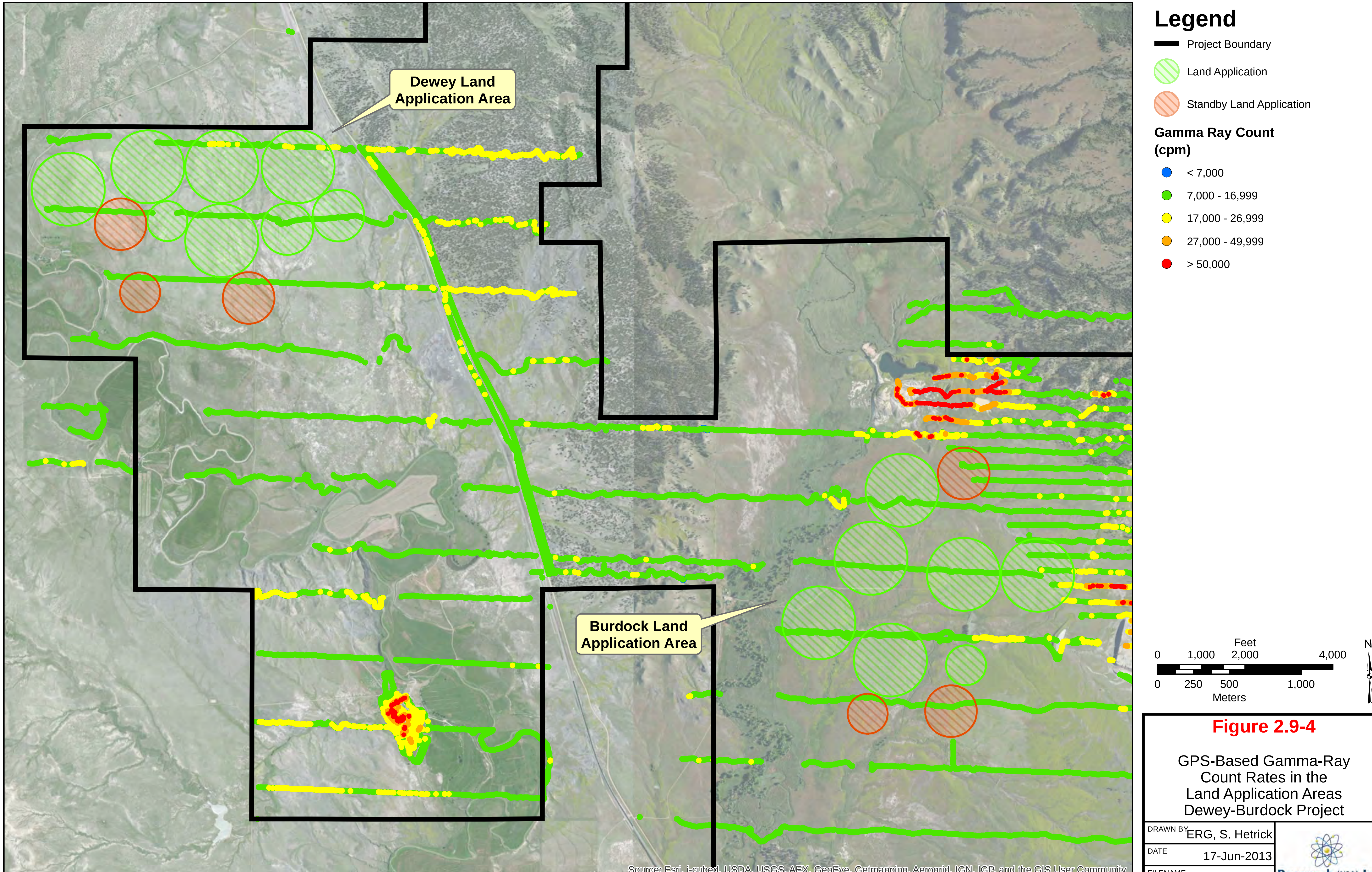

Figure 2.9-4

GPS-Based Gamma-Ray Count Rates in the Land Application Areas Dewey-Burdock Project

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

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

Exposure Rate = 0.0007 x Gamma Count Rate + 2.02

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

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

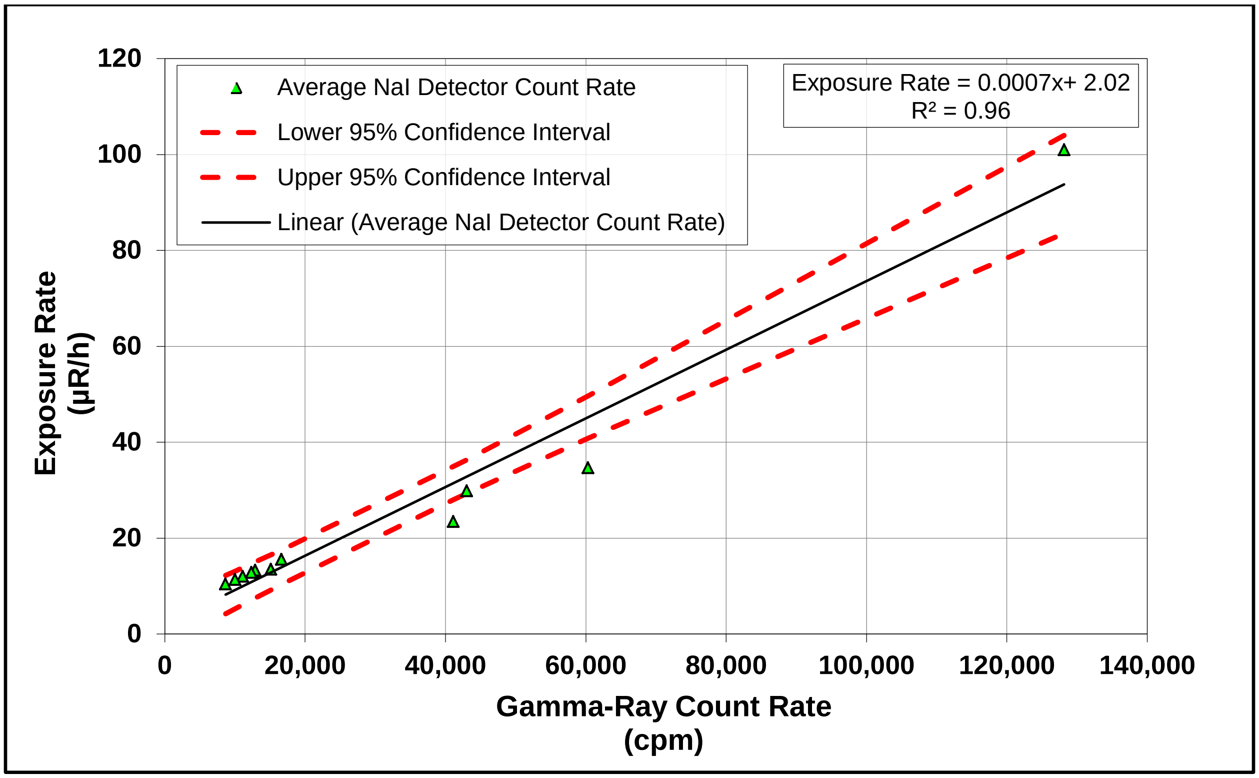

Figure 2.9-5: Linear Regression of Gamma Count Rate Data and PIC Measurements, Including the 95% Confidence Interval

The linear regression model predicts an average exposure rate of 10.9 μR/hr for the site. The range of predicted exposure rates is 5.9 to 324 μR/hr, based on a minimum count rate cutoff of 5,500 cpm and the maximum observed gamma count rate of 460,485 cpm. The predicted site-wide exposure rates are shown on Figure 2.9-6. ArcView GIS was used to map gamma survey

data. The input parameters to ArcView GIS were gross gamma-ray count rates, in counts per minute (cpm), measured using matched sodium iodide detectors and recorded during the GPS-based survey. The results obtained from ArcView GIS were the predicted exposure rates, in μR/hr, calculated using the equation given above. Figure 2.9-6 is intended for informational purposes only, to qualitatively evaluate the relative spatial distribution of exposure rates across the project area. No interpolation or other method to spatially predict gamma exposure rate within the project area was used.

The error estimates associated with the data on Figure 2.9-6 are based on the linear regression correlation of the gamma count rate data and PIC measurements. The 95 percent confidence interval of the regression line is shown in Figure 2.9-5. For predicted exposure rates near the median gamma count rate, the upper and lower 95 percent confidence limits are within 35% of the predicted value.

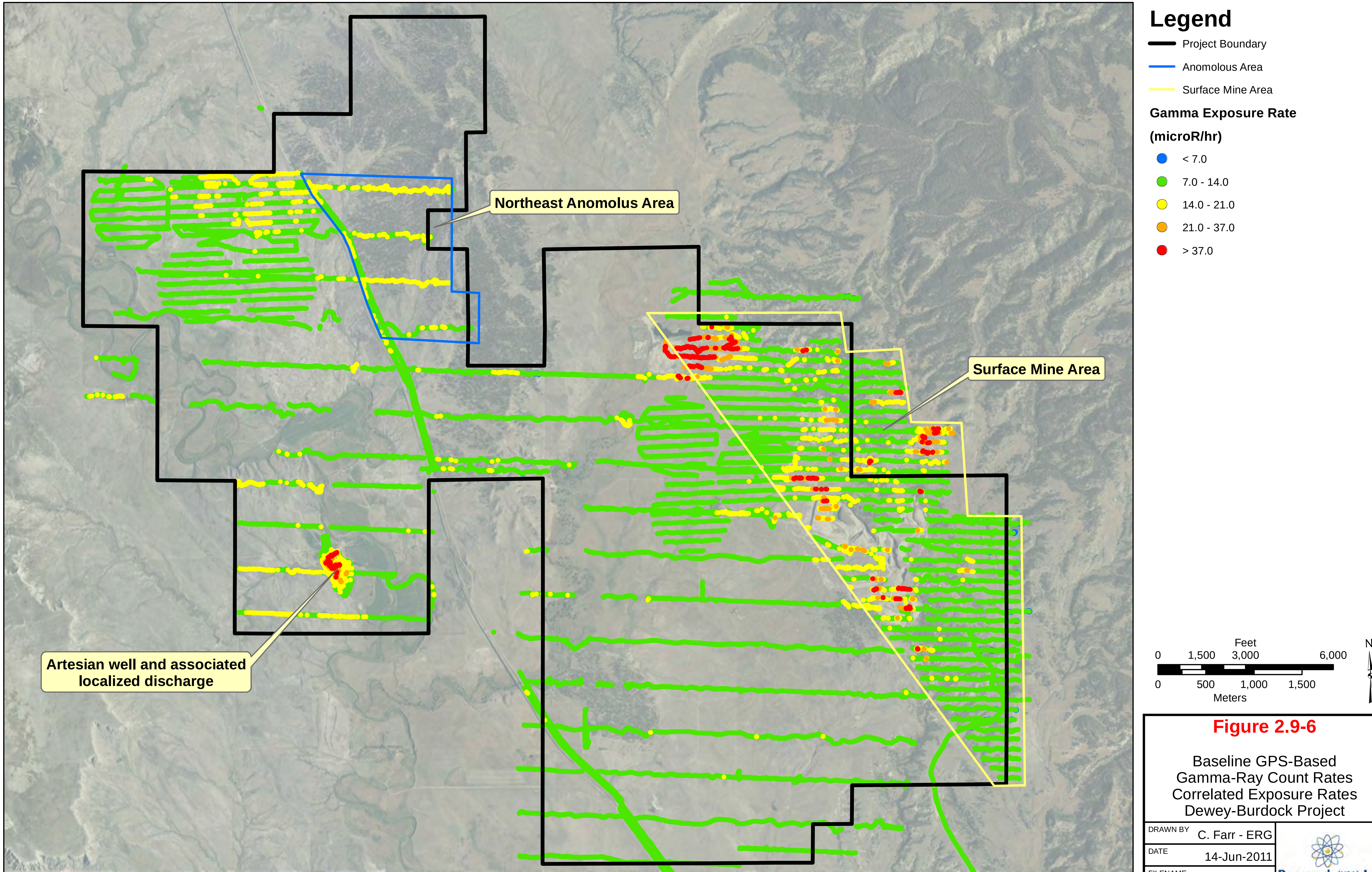

Figure 2.9-6

Baseline GPS-Based Gamma-Ray Count Rates Correlated Exposure Rates Dewey-Burdock Project

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FILENAME	Figure 2.9-6.mxd

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

Linear regression modeling was used to provide a correlation between the concentration of Ra-226 in soil and the gamma count rate. This is standard industry practice. For decades the uranium industry decommissioning programs have relied on gamma count rate/Ra-226 correlations to identify land areas with Ra-226 contaminated soils requiring removal.

Two linear regression models were developed. The equations and descriptive statistics for each model are shown in Table 2.9-4. Equation 2.1 was developed using all soil data, while Equation 2.2 was developed using the same data but with five outliers excluded. The R^2 value for Equation 2.1 is higher than Equation 2.2. While the higher R^2 value often indicates a better fit, in this case Equation 2.2 better represents the concentrations of Ra-226 in soil as described below.

Plots of residuals (actual data minus predicted values from the equations) for both equations show increasing deviation with increasing gamma count rate. This is demonstrated in Figures 2.9-6a and 2.9-6b. This increasing deviation violates the assumption of constant variance that is used in linear regression. Therefore, the use of R^2 as a measure of the adequacy of a model is not appropriate.

Equation 2.2 (the linear regression model with five outliers excluded) was selected based on an evaluation of results of data analysis that compare the two linear regression models using two distinct equations, which indicated that the selected equation produced the best fit of data. Instead of using the R^2 value, the model predictions were directly compared to the data by examining the median and quartiles. The median and quartiles predicted by Equation 2.2 are very close to the median and quartiles of the data and are much closer than the median and quartiles of Equation 2.1. Therefore, Equation 2.2 was used to predict concentrations of Ra-226 in soil.

Table 2.9-4: Predicted Radium-226 Concentrations from Two Linear Regression Models Compared to Actual Data

Linear Regression Model Equation	Soil Data	R^2	Gamma Count Rate (All) (cpm)	Predicted Ra-226 Soil Concentration (pCi/g)
2.1) [Ra-226] = -0.87 + 0.0002*GCR	All	0.75	Median (12,687)	1.7
			1st Quartile (11,395)	1.4
			3rd Quartile (14,437)	2.0
2.2) [Ra-226] = -1.04 + 0.000187*GCR	5 outliers removed	0.43	Median (12,687)	1.4
			1st Quartile (11,395)	1.1
			3rd Quartile (14,437)	1.7
Actual Soil Data	All	NA	Median	1.3
			1st Quartile	1.1
			3rd Quartile	1.7
GCR = gamma count rate				

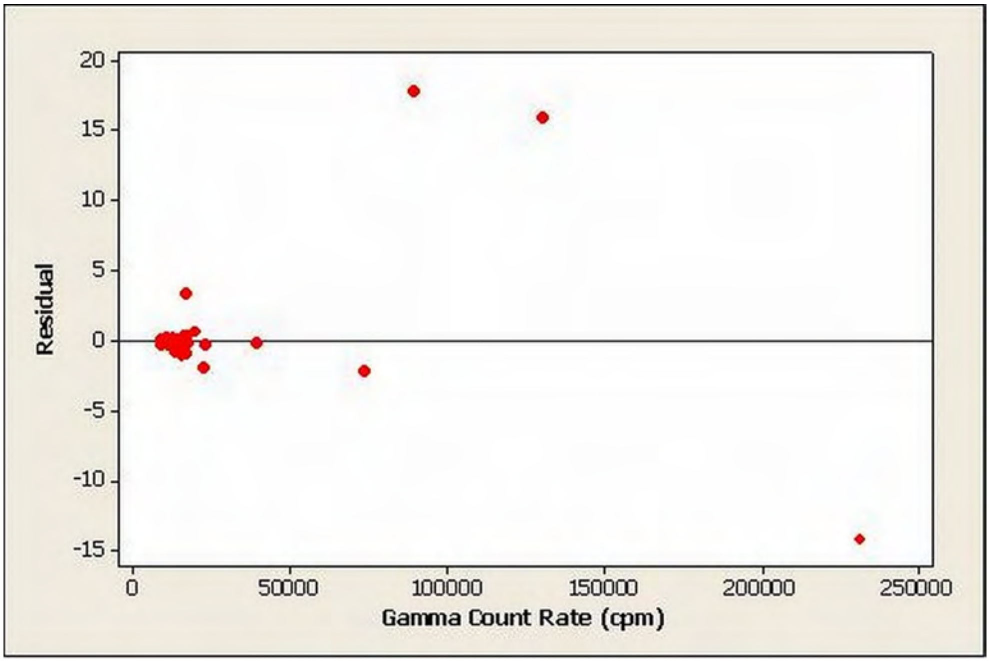

Figure 2.9-6a: Plot of Residuals versus Gamma Count Rate for the Linear Regression Equation 2.1

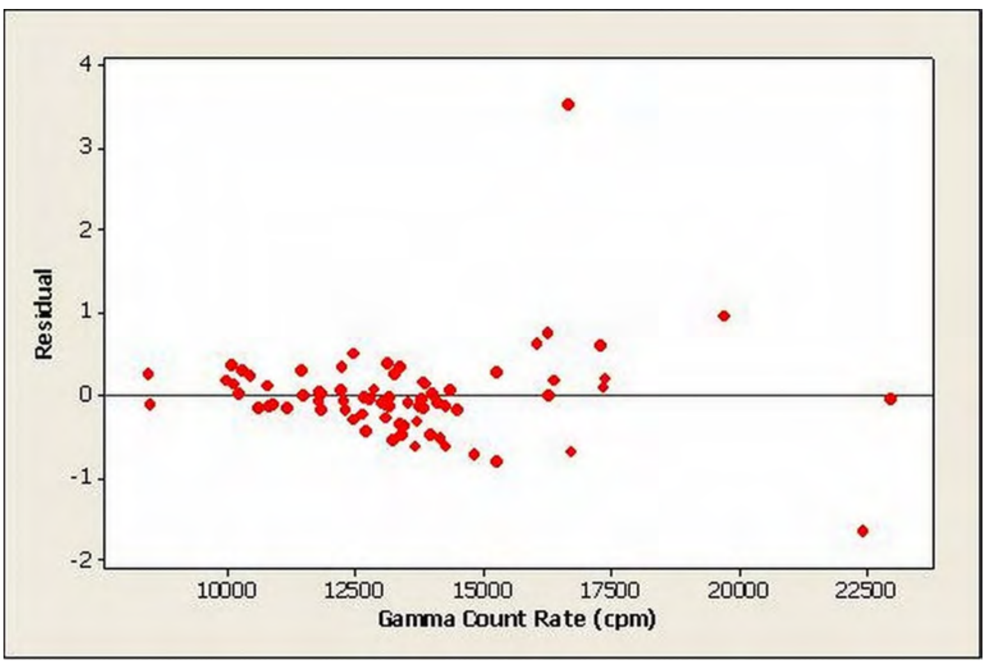

Figure 2.9-6b: Plot of Residuals versus Gamma Count Rate for the Linear Regression Equation 2.2

2.9.2.2.4 Final Gamma Exposure Rate Mapping

As stated in Section 2.9.2.2.2, the linear regression model correlating sodium iodide detector readings to PIC measurements predicts a site-wide average exposure rate of 10.9 µR/hr. The range of predicted exposure rates is 5.9 to 324 µR/hr, based on the observed gamma-ray count rates at the site. As indicated on Figure 2.9-6, predicted exposure rates ranging from 21 to greater than 37 µR/hr occur in the open pit mine areas, near the artesian well and its localized discharge areas, and in rocky outcrop areas in the northwest corner of the surface mine area. Predicted exposure rates in the anomalous area in the northern portion of the main permit area range from 7 to 21 µR/hr.

2.9.2.2.5 Soil Ra-226 Concentration Mapping

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

Figure 2.9-7 is intended for information purposes only, to qualitatively evaluate the relative spatial distribution of Ra-226 concentrations in soil across the project area. No interpolation or other method to spatially predict Ra-226 concentrations within the project area was used.

The error associated with the predicted values in Figure 2.9-7 is coupled with the error of the regression line. A 95% confidence interval for the regression line used to predict radium-226 concentration is shown in Figure 5-2 of Appendix 2.9-A. The 95% confidence interval across the range of typical gamma count rates spans approximately 2 pCi/g. Provided future gamma count rates are collected using similar instrumentation and during a similar seasonal period as the existing data, little seasonal variability would be introduced. If soil moisture conditions are much different when collecting future gamma count rate data, new correlations to radium-226 concentrations in soil will be established for the specific condition.

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

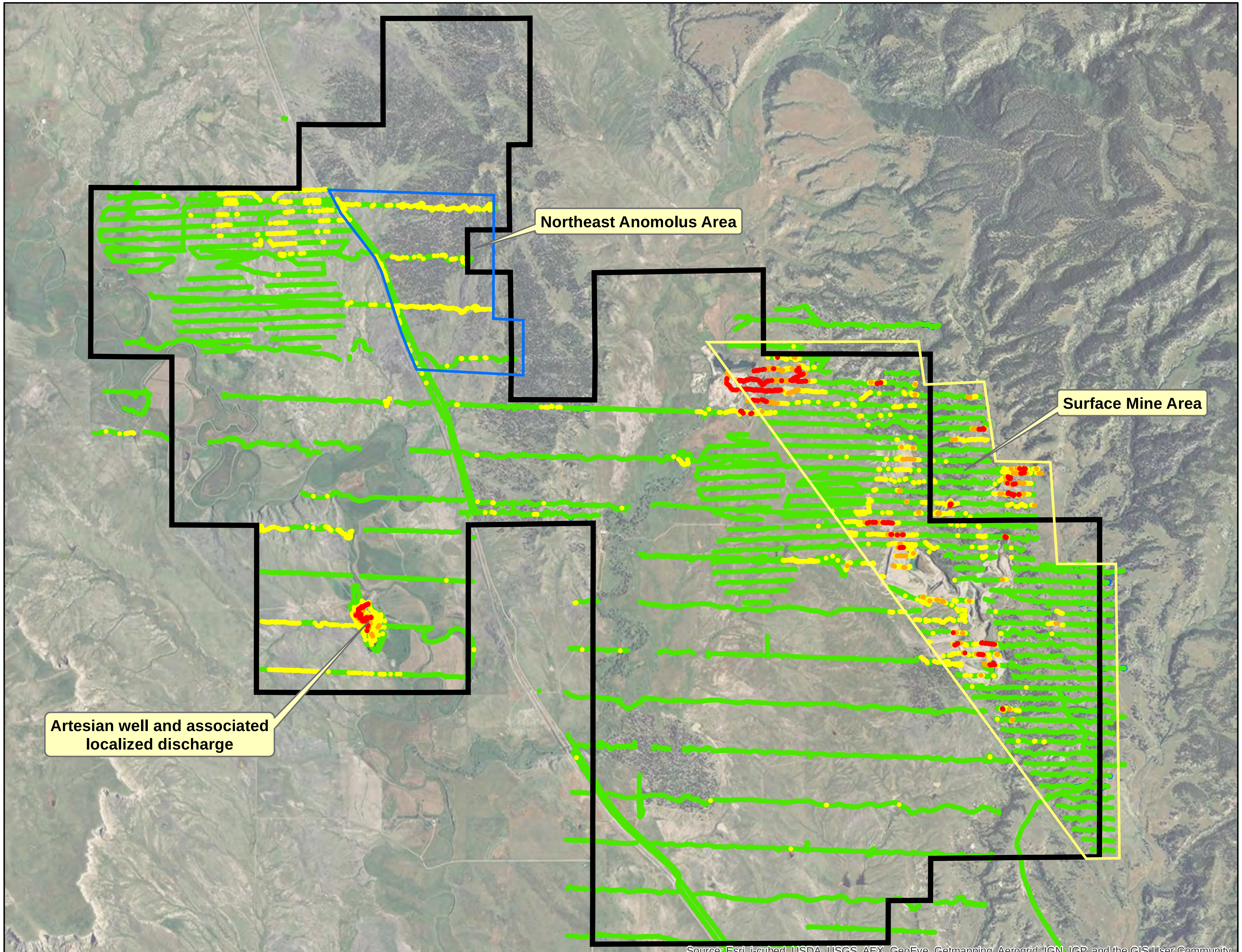

Figure 2.9-7

Baseline GPS-Based Gamma-Ray Count Rates Correlated Ra-226 Concentrations Dewey-Burdock Project

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DATE 17-Jun-2013

FILENAME Gamma-Ra226CountRate.mxd

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2.9.3 Soil Sampling

2.9.3.1 Methods

2.9.3.1.1 Surface and Subsurface Soil Sampling

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

The general soil sampling strategy is described below, but the following key points are emphasized.

1) The Dewey-Burdock project area was treated as one "milling site," not as two separate "milling sites." For pre-operational baseline characterization, Powertech (USA) contends that this is appropriate, since one continuous license area is proposed and the locations of well fields, processing facilities, and land application areas within that license area are arbitrary when evaluating the average pre-operational radiological conditions.
2) The radial pattern sample point distribution recommended in Regulatory Guide 4.14 was not used due to the configuration of proposed ISR facilities. Most soil sample locations were based on a combination of random and biased sampling. Random sampling was intended to evaluate the central tendency (mean or median) of the radionuclide concentrations in soil, while the biased sampling was focused on defining the range of radionuclide concentrations in soil, within the project area. The gamma survey data were used to help locate the bias sampling locations. An exception to this method was that soil samples were collected at air particulate monitoring locations, consistent with Regulatory Guide 4.14.
3) Initially, the total number of biased and random samples was 80. Regulatory Guide 4.14 recommends 40 radially spaced samples from a depth interval of 0-5 cm, while NUREG-1569 recommends an additional 40 soil samples from a depth interval of 0-15 cm co-located with the 0-5 cm sample locations. In addition to the 40 radially spaced soil samples, Regulatory Guide 4.14 recommends soil sampling (0-5 cm depth interval) from the air particulate monitoring locations. An additional 17 random soil sample locations were later added in the proposed land application areas.
4) The approach was to focus the baseline soil investigation on the 0-15 cm depth intervals and limit soil sampling of the 0-5 cm depth interval to the air particulate monitoring locations, while keeping the total number of samples greater than or equal to those recommended by Regulatory Guide 4.14 and NUREG-1569 the same, which is 80 samples. The rationale for this approach includes the following items:

a. The 0-5 cm depth interval is more sensitive to aerial deposition of radionuclides than the 0-15 cm depth interval, and it therefore makes sense to sample the more sensitive depth interval where air particulate monitoring is taking place.

b. The 0-5 cm depth interval sampling at air particulate monitoring stations will be part of the operational monitoring program, thus operational monitoring data can be compared to baseline monitoring data at consistent depth intervals.

c. The radium-226 soil cleanup standard contained in 10 CFR 40, Appendix A is defined as 5 pCi/g above background for a depth interval of 0-15 cm.

d. An emphasis on the depth interval applicable to the radium-226 cleanup standard was used since this standard requires a well-defined pre-operational characterization of background radiological conditions in soil from a depth of 0-15 cm.

5) Consistent with Regulatory Guide 4.14 recommendations, all soil samples were analyzed for radium-226, while 10% of the soil samples were also analyzed for natural uranium, thorium-230 and lead-210. All soil samples collected at the air particulate monitoring locations were analyzed for natural uranium, thorium-230, radium-226, and lead-210.

The box plot in Figure 2.9-7a demonstrates that the median Ra-226 concentrations in the 0-5 cm and 0-15 cm soil depth interval are similar. Collecting additional 0-5 cm depth interval soil samples and analyzing for Ra-226 would not provide additional information.

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

RG 4.14 suggests the collection of 40 samples from 0 to 5 cm. NUREG-1569 suggest the collection of samples at 0 to 15 cm. To avoid any ambiguity in the interpretation of these guidance documents, Powertech (USA) chose to collect 80 samples at 0 to 15 cm and

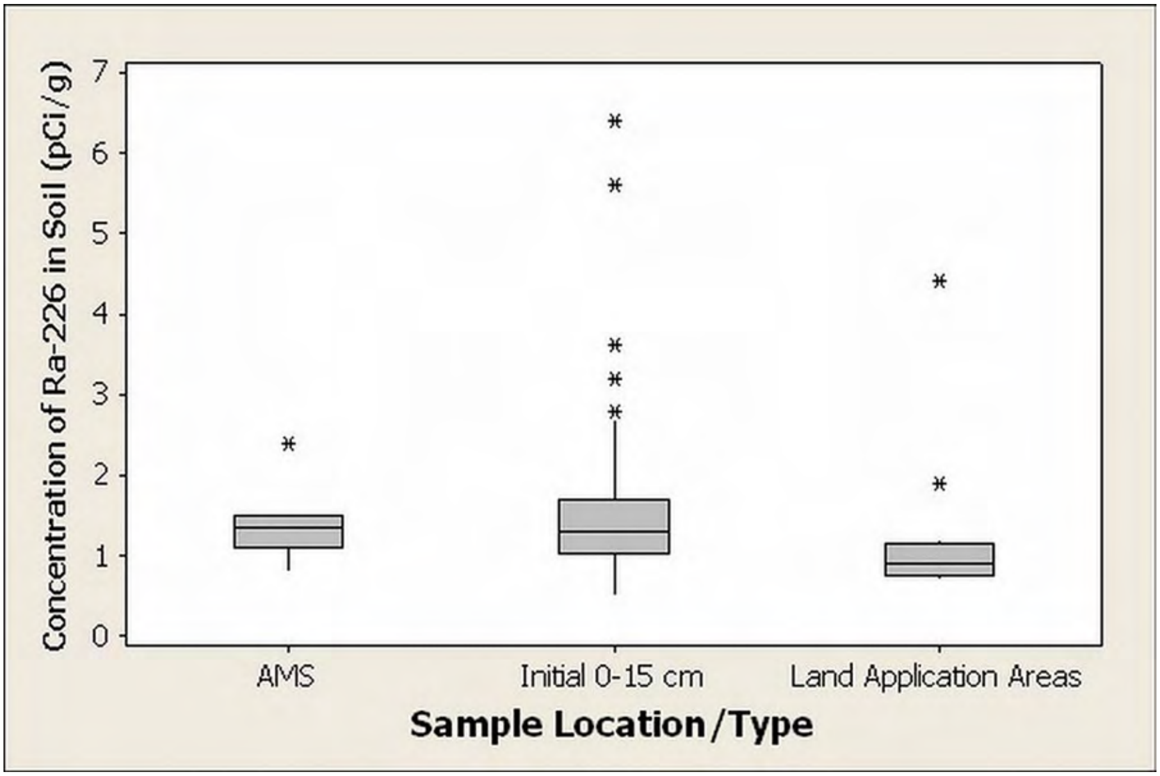


Figure 2.9-7a: Box and Whisker Plot of Ra-226 Concentrations in Surface Soil at Depths of 0-5 cm (AMS), 0-15 cm (Initial 0-15 cm), and 0-15 cm (Land Application Areas)

supplementing the sampling effort with Global Positioning System (GPS)-based gamma radiation surveys. The GPS-based surveys allow orders of magnitude more data to be obtained with a similar effort. Owners of uranium recovery sites that have or are undergoing decommissioning are finding that extensive baseline data are invaluable. In conjunction with soil sampling and analysis and cross-reference to PIC measurements, the GPS-based gamma surveys can be used to predict site-wide concentrations of gamma-emitting radionuclides and/or exposure rates. Spatial trends in gamma emissions (and radionuclide concentrations as surrogates) are also far more apparent through the use of GPS-based gamma surveys than soil sampling alone. As will be shown below, reliance on a random soil sampling program alone would not have identified elevated areas of radioactivity at the site.

The following discussion provides justification for the number of samples collected in the Dewey and Burdock portions of the project area. Powertech (USA) acknowledges that there was a difference in sample density between the Dewey and Burdock portions of the project area and commits to collecting additional soil samples in the Dewey area prior to ISR operations.

Dewey Area

Table 2.9-4a describes the samples collected in the Dewey portion of the project area. These samples include random and biased locations within the general Dewey area as well as the Dewey land application area. The sample locations were focused on the roll-front areas, land application areas and in an area exhibiting higher gamma readings in the north and northeast part of the Dewey area. Sample locations have been plotted on Figure 2.9-9 to show their relationship to proposed process-related features.

Burdock Area

Table 2.9-4b describes the samples collected in the Burdock portion of the project area. These samples include random and biased locations within the Burdock area. The sample locations were focused on the roll-front areas and land application areas. Sample locations have been plotted on Figure 2.9-9 to show their relationship to proposed process-related features.

Since the pre-operational soil sampling strategy treated the entire project area as one "mill site" as discussed above, Powertech (USA) proposes to evaluate adequate sample numbers for the entire project area, not sub-areas. Nevertheless, Powertech (USA) acknowledges that there was a difference in sample densities between the Dewey and Burdock portions of the project area and commits to additional soil sampling in the Dewey area as described below.

Table 2.9-4a: Dewey Area Soil Samples

Sample ID	Depth (cm)	Analytes
MPA-R01	0-15	Radium-226
NEA-R01	0-15	Full List
NEA-R02	0-15	Radium-226
NEA-R03	0-15	Radium-226
NEA-R04	0-15	Radium-226
NEA-R05	0-15	Radium-226
RFA-B01	0-15, 15-30, 30-100	Full List
RFA-B03	0-15	Radium-226
RFA-B06	0-15	Radium-226
RFA-B10	0-15	Radium-226
RFA-B13	0-15, 15-30, 30-100	Radium-226
RFA-B14	0-15cm	Radium-226
RFA-B17	0-15, 15-30, 30-100	Radium-226
RFA-B18	0-15	Radium-226
RFA-B23	0-15	Radim-226
RFA-B25	0-15	Full List
RFA-B28	0-15	Radium-226
RFA-B30	0-15, 15-30, 30-100	Radium-226
RFA-B41	0-15	Radium-226
RFA-B43	0-15	Radium-226
RFA-B45	0-15	Radium-226
LAN-001	0-15, 15-30, 30-100	Full List
LAN-002	0-15, 15-30, 30-100	Full List
LAN-003	0-15, 15-30, 30-100	Full List
LAN-004	0-15, 15-30, 30-100	Full List
LAN-005	0-15, 15-30, 30-100	Full List
LAN-006	0-15, 15-30, 30-100	Full List
LAN-007	0-15, 15-30, 30-100	Full List
LAN-008	0-15, 15-25 , Refusal at 25	Full List
LAN-009	0-15, 15-30, 30-100	Full List
LAN-010	0-15, 15-30, 30-100	Full List

Note: “Full List” includes natural uranium, radium-226, thorium-230 and lead-210.

Table 2.9-4b: Burdock Area Soil Samples

Sample ID	Depth (cm)	Analytes
MPA-R02	0-15	Radium-226
MPA-R03	0-15	Full List
MPA-R04	0-15	Radium-226
MPA-R05	0-15	Radium-226
MPA-B01	0-15	Radium-226
MPA-B02	0-15	Radium-226
MPA-B03	0-15	Radium-226
RFA-B02	0-15, 15-30, 30-100	Radium-226
RFA-B04	0-15	Radium-226
RFA-B07	0-15	Radium-226
RFA-B08	0-15	Radium-226
RFA-B09	0-15	Radium-226
RFA-B11	0-15	Full List
RFA-B12	0-15	Radium-226
RFA-B15	0-15, 15-30, 30-100	Radium-226
RFA-B16	0-15	Radium-226
RFA-B19	0-15	Radium-226
RFA-B20	0-15	Full List
RFA-B21	0-15, 15-30, 30-100	Radium-226
RFA-B22	0-15	Radium-226
RFA-B24	0-15	Radium-226
RFA-B26	0-15	Radium-226
RFA-B27	0-15	Radium-226
RFA-B29	0-15	Radium-226
RFA-B31	0-15	Radium-226
RFA-B33	0-15	Radium-226
RFA-B34	0-15	Radium-226
RFA-B35	0-15	Radium-226
RFA-B36	0-15, 15-30, 30-100	Radium-226
RFA-B37	0-15, 15-30, 30-100	Radium-226
RFA-B38	0-15	Radium-226
RFA-B39	0-15	Radium-226
RFA-B40	0-15	Full List
RFA-B44	0-15	Radium-226
LAS-001	0-15, 15-30, 30-100	Full List
LAS-002	0-15, 15-30, 30-100	Full List
LAS-003	0-15, 15-30, 30-100	Full List
LAS-004	0-15, 15-30, 30-100	Full List
LAS-005	0-15, 15-30, 30-100	Full List
LAS-006	0-15, 15-30, 30-100	Full List
LAS-007	0-15, 15-30, 30-100	Full List

Note: “Full List” includes natural uranium, radium-226, thorium-230 and lead-210.

Powertech (USA) chose to use methods contained in NUREG/CR-5849, "Manual for Conducting Radiological Surveys in Support of License Termination" (NRC, 1992) to evaluate the sample number adequacy. The land application area sample results (sample ID designations LAS and LAN) were not used in the evaluation, since they were not part of the initial 80 soil samples. NUREG/CR-5849 describes a method to determine an adequate sample size (N), where t is the t-statistic, r is the relative fractional error, and cv is the coefficient of variation.

$$N > \left(\frac{t}{r} cv \right)^2$$

A 95% confidence level with the degrees of freedom approaching infinity yields a t-statistic of 1.645. Figure 2.9-7b shows the plot of this equation for a relative fraction error of 10 and 20 percent for various values of coefficient of variation.

The mean and standard deviation of the radium-226 concentrations in the 55 samples collected in the Main Permit Area are 1.51 and 0.77 pCi/g, respectively. The coefficient of variation for the samples is 0.77/1.51=0.5. Inspection of the plot in Figure 2.9-7b indicates that about 20 and 70 samples are sufficient to estimate the mean radium-226 concentration to within 20 and 10 percent, respectively. The collection of 55 samples is acceptably within this range. The addition of 17 land application samples exceeds this range. Based on this evaluation, Powertech (USA) concluded that an adequate number of soil samples were collected to describe the mean radium-226 concentration in the entire project area to within 10 percent.

<u>Commitment to Collect Additional Soil Samples</u>

Powertech (USA) acknowledges a difference in sample density (number of samples per unit area) between the Burdock and Dewey areas. The Burdock area has a higher sample density, which the NRC staff has stated is probably sufficient for the pre-operational baseline sampling program. Powertech (USA) commits to collecting 15 more surface soil samples (0-15 cm) in the Dewey area. The proposed locations of these additional samples are shown in Figure 2.9-7c. The samples will be analyzed for parameters consistent with the recommendations of Regulatory Guide 4.14, including the suggested LLDs. This additional sampling will result in equal sample densities for the Dewey and Burdock portions of the project area.

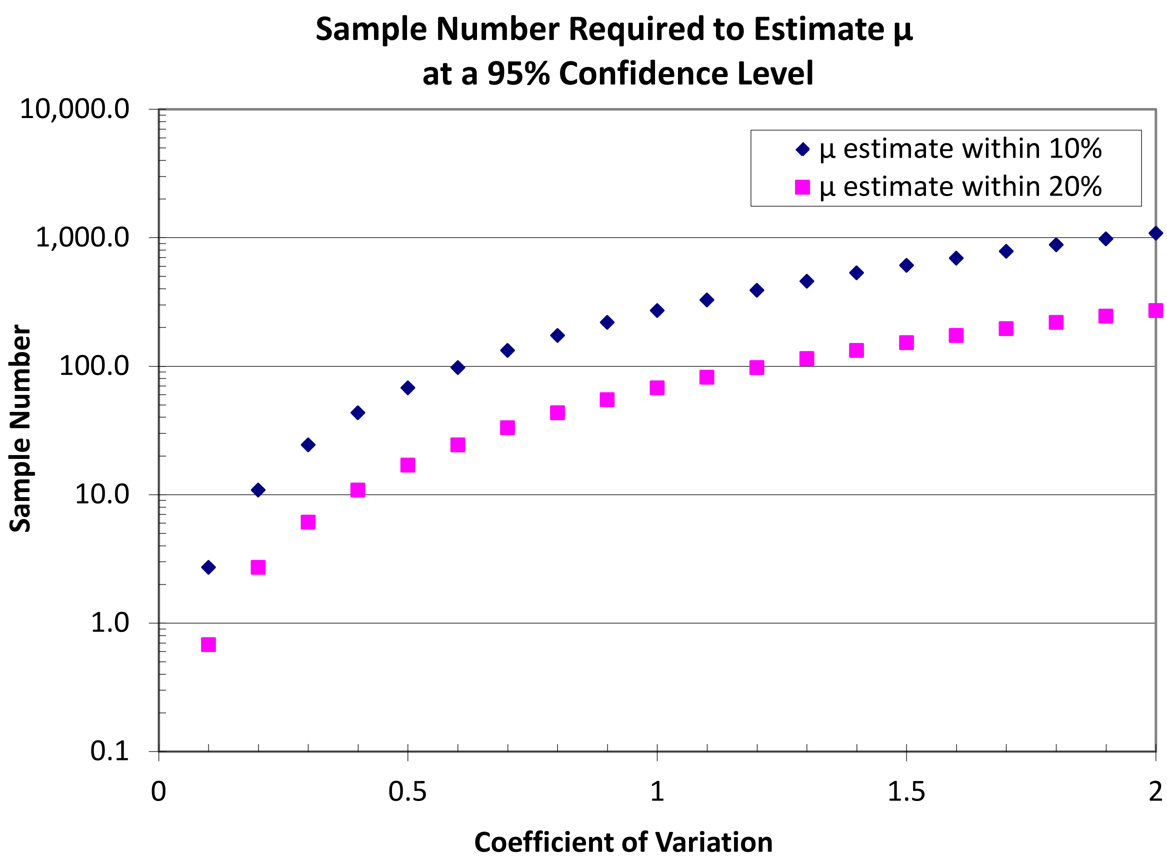
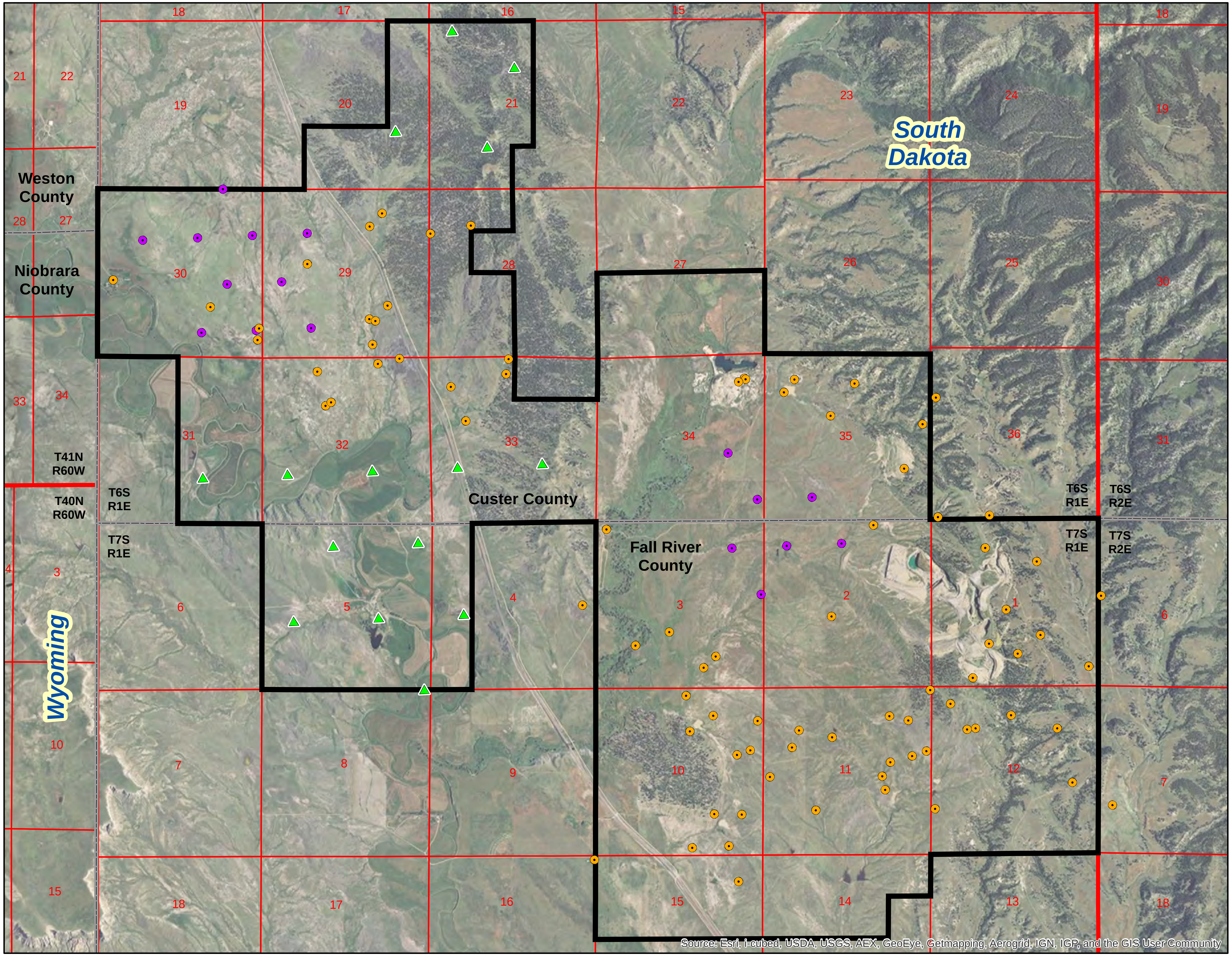


Figure 2.9-7b: Adequate Sample Size as a Function of the Coefficient of Variation



Legend

- Project Boundary
- Proposed Soil Sample Location
- Existing Surface Soil Sample Location
- Existing Land Application Area Soil Sample Location

Feet: 0 1,500 3,000 6,000

Meters: 0 500 1,000 1,500

N

Figure 2.9-7c

Additional Dewey Area Surface Soil Sample Locations

Dewey-Burdock Project

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Main Permit and Surface Mine Areas

The soil sampling strategy for the main permit and surface mine areas of the project site consisted of biased and random sampling at the eight AMS locations shown in Figure 2.9-8 (this figure also shows the locations of the radon flux and track etch detector measurements, discussed below) and 80 additional locations shown in Figure 2.9-9. Biased samples were collected at 5 of the 80 locations; the remainder was placed randomly, using Visual Sampling Plan (VSP), Version 5.0. For the Main Permit Area and Surface Mine Area, the input to VSP consisted of shape files of the proposed license boundary and Surface Mine Area and the number of samples (75) for the Main Permit Area and Surface Mine Area. Refer to Figure 2.9-6 for the locations of the Main Permit Area and the Surface Mine Area. For the Land Application Areas, the input to VSP consisted of shape files of the Land Application Areas and the number of samples (17) for the Land Application Areas. Land Application Areas are shown on Figure 3.1-1. The results obtained from VSP consisted of coordinates for soil samples in the Main Permit Area and Land Application Areas. These locations are shown on Figures 2.9-9 and 2.9-10. The biased samples were obtained in the surface mine area and selected to bound the upper range of radionuclide concentrations. The five biased samples are not sufficient to characterize radium-226 concentrations in impacted areas.

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

- Radium-226 via gamma spectroscopy or radon emanation: EPA Methods 901.1 and 903.1, respectively. *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA/600/4-80-032), August 1980. The majority of radium-226 analyses were performed using EPA Method 901.1. Clarification from the contract laboratory, Energy Laboratories, Inc., on the testing method used for Ra-226 soil sample analyses, is provided in Appendix 2.9-G. The type of gamma analysis performed on the soil samples to determine the Ra-226 concentrations was closed-can gamma analysis in a 3-in can filled with 150 to 200 grams of soil. The soil is dried, ground, split, canned and taped in accordance with EPA Method 901.1. The Ra-226 concentrations were determined by measuring the 609 keV peak from bismuth-214.

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

- Natural Uranium: EPA 6020 ICP-MS, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846), June 2007. Consistent with Regulatory Guide 4.14, a laboratory performance evaluation for uranium in a soil matrix using EPA Method 6020A is provided as Appendix 2.9-F. The performance evaluation was performed by RTC Corp. (A2LA Accreditation No. 2122.01) for the accreditation provided by the American Association for Laboratory Accreditation (A2LA). The performance evaluation is for the period July 30 through September 12, 2008, which is the time period during which the soil samples from the land application areas were analyzed. The initial 80 soil samples were analyzed in late 2007. The evaluation indicates that Method 6020A is used by the laboratory for analysis of uranium in soil and that it provides an acceptably accurate measurement of uranium in a soil matrix.

- Lead-210: EPA Method 909, *Determination of Lead in Drinking Water* (EPA, 1982). This method was selected by the contract laboratory, Energy Laboratories, Inc., as the preferred test method. A copy of EPA Method 909 (EPA, 1982), is provided as Appendix 2.9-E. Although EPA Method 909 was developed by EPA personnel and can be found on the EPA test method website (http://www.epa.gov/ne/info/testmethods), EPA Method 909 is not an EPA-approved procedure. Powertech (USA) understands that EPA does not have an approved procedure for lead-210 in water or soil.

- EPA Method 3050B, *Acid Digestion of Sediments, Sludges, and Soils,* was used to convert the soil into an aqueous matrix (EPA, 1996). This procedure is provided as Appendix 2.9-D.

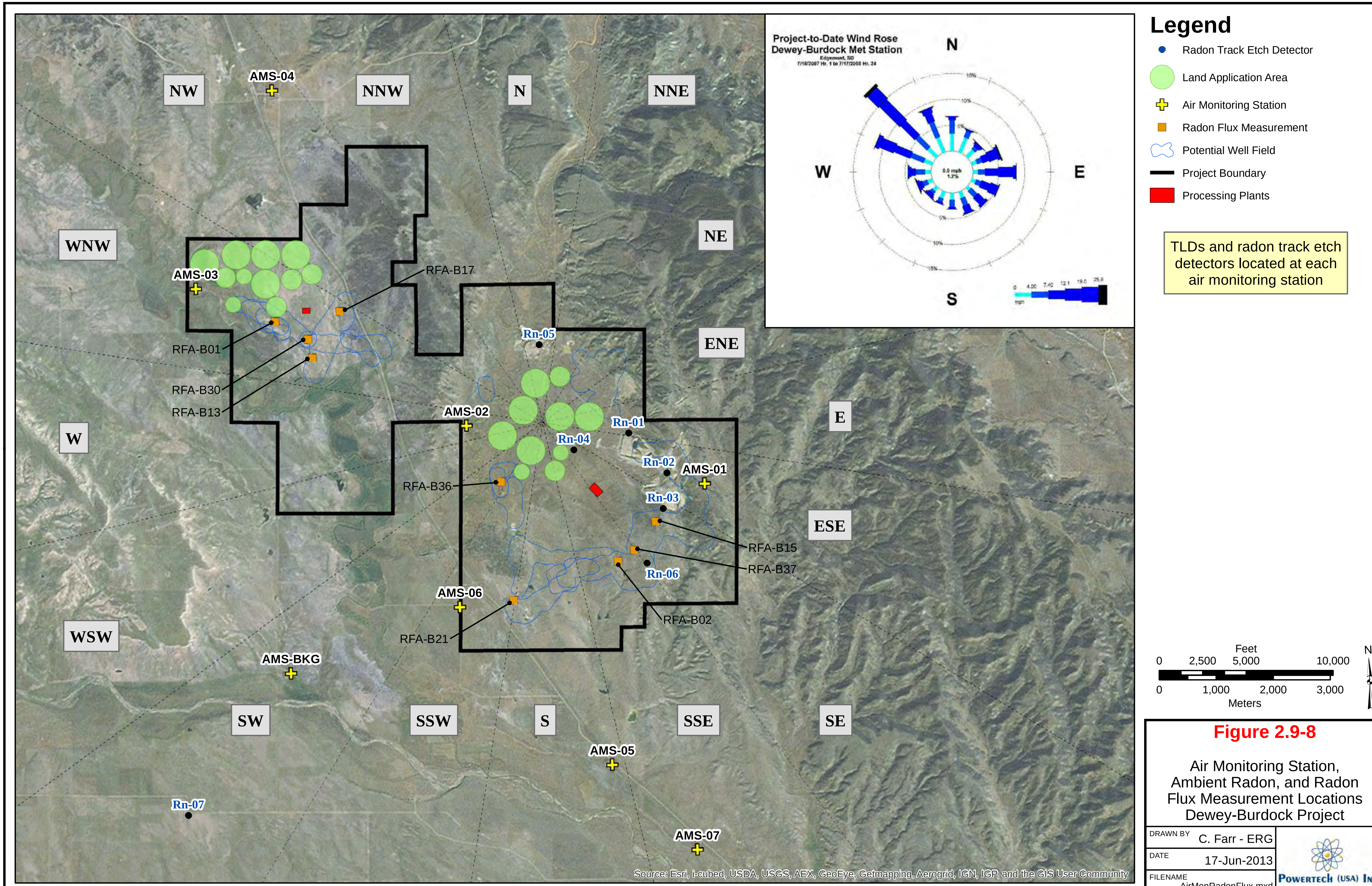

Figure 2.9-8

Air Monitoring Station, Ambient Radon, and Radon Flux Measurement Locations Dewey-Burdock Project

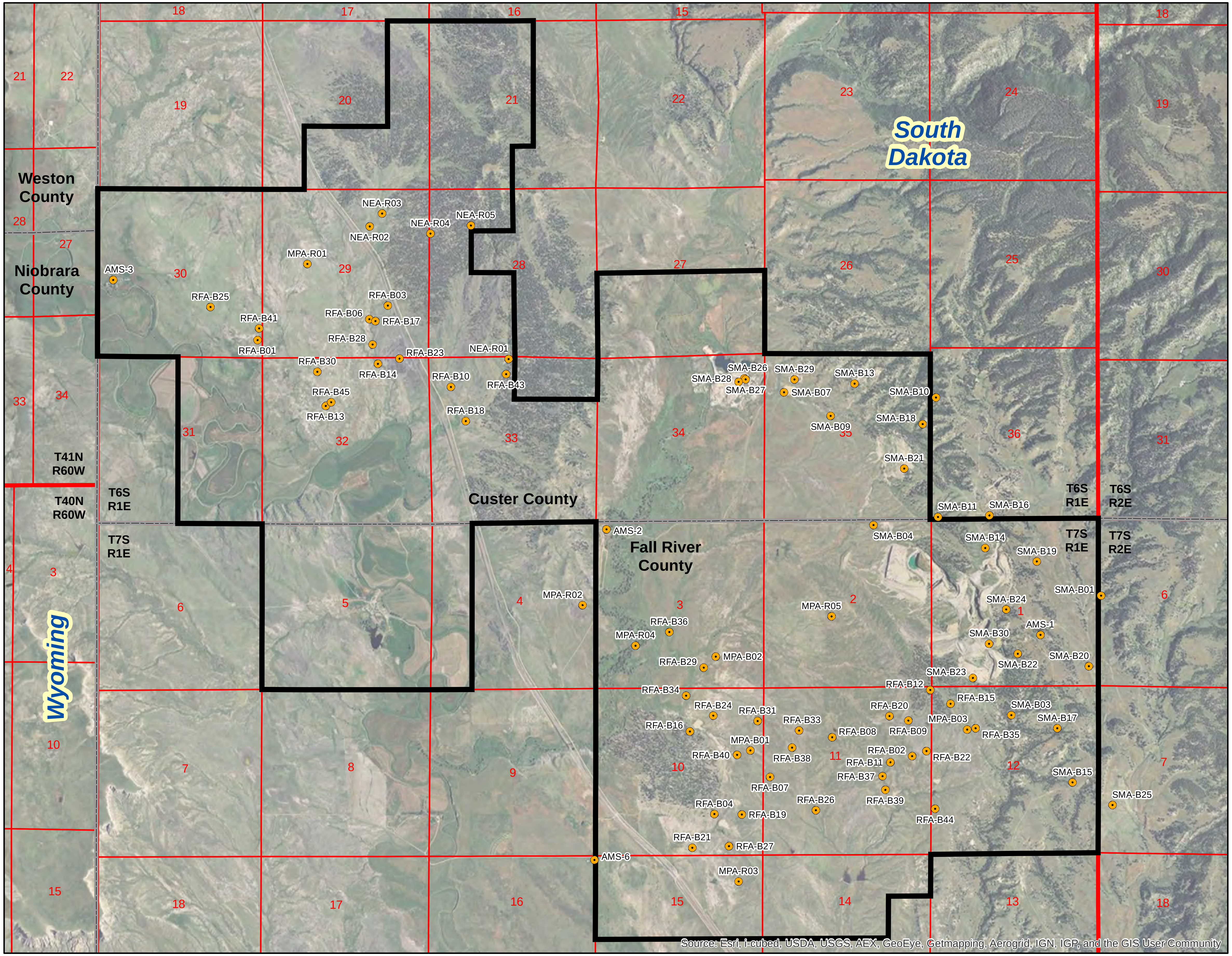

Figure 2.9-9

Surface Soil Sample Locations
(80 Locations Total)

Dewey-Burdock Project

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.

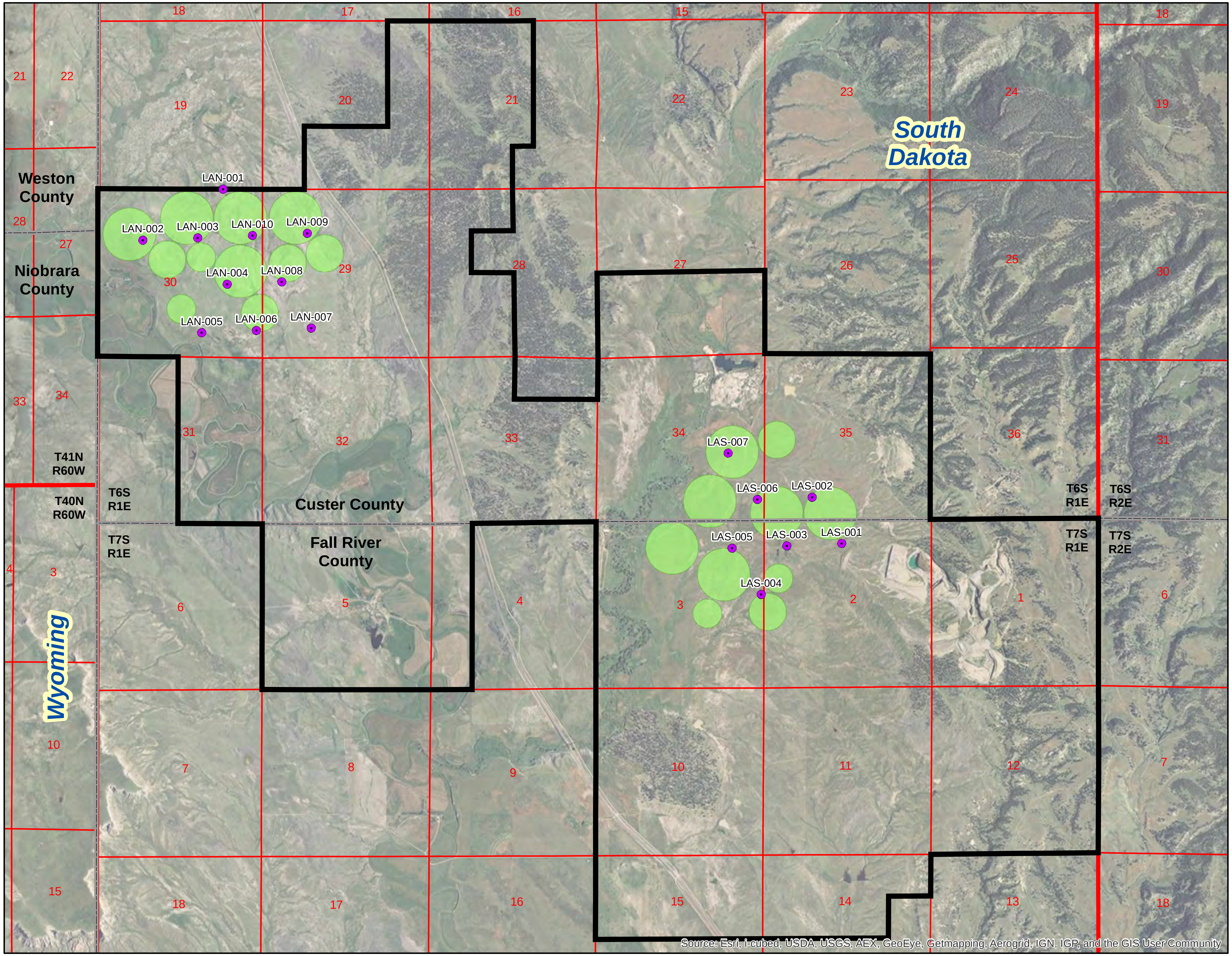

Figure 2.9-10

Soil Sample Locations in Land Application Areas

Dewey-Burdock Project

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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 (sometimes designated as HV for high-volume air samplers)
- SMA: surface mine area
- MPA: main permit area
- NEA: northeast area
- RFA: roll front area
- LAN: land application area north (Dewey)
- LAS: land application south (Burdock)

Table 2.9-5: Radionuclide Concentrations in All Soil Samples

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

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

Sample ID	Date Collected	Depth (cm)	Gamma Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
RFA-B08	9/25/2007	0-15	13433	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B08-Dup	9/25/2007	0-15	13528	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B09	9/25/2007	0-15	14825	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B10	9/25/2007	0-15	13366	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B11	9/25/2007	0-15	14253	8.8E-07	1.0E-06	2.0E-07	5.0E-07	1.0E-07	1.8E-06	3.0E-07	2 E-8	1 E-07	1 E-07	1 E-07
RFA-B12	9/25/2007	0-15	13135	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B13A	9/26/2007	0-15	13987	-	-	-	-	-	1.8E-06	3.0E-07	-	-	-	1 E-07
RFA-B14	9/25/2007	0-15	13872	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B15A	9/26/2007	0-15	13535	-	-	-	-	-	1.4E-06	3.0E-07	-	-	-	1 E-07
RFA-B16	9/25/2007	0-15	13675	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B17A	9/26/2007	0-15	16283	-	-	-	-	-	2.0E-06	3.0E-07	-	-	-	1 E-07
RFA-B18	9/25/2007	0-15	13835	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B19	9/25/2007	0-15	13689	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B20	9/25/2007	0-15	13113	8.8E-07	1.0E-06	2.0E-07	5.0E-07	1.0E-07	1.3E-06	3.0E-07	1.9E-8	1 E-07	1 E-07	1 E-07
RFA-B21A	9/26/2007	0-15	16641	-	-	-	-	-	5.6E-06	4.0E-07	-	-	-	1 E-07
RFA-B22	9/25/2007	0-15	14087	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
RFA-B23	9/25/2007	0-15	19674	-	-	-	-	-	3.6E-06	4.0E-07	-	-	-	1 E-07
RFA-B24	9/25/2007	0-15	12766	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07
RFA-B25	9/25/2007	0-15	10300	6.7E-07	1.0E-06	2.0E-07	4.0E-07	1.0E-07	1.2E-06	2.0E-07	1.9E-8	1 E-07	1 E-07	1 E-07
RFA-B26	9/25/2007	0-15	11791	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B27	9/25/2007	0-15	13794	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
RFA-B28	9/25/2007	0-15	15246	-	-	-	-	-	2.4E-06	3.0E-07	-	-	-	1 E-07
RFA-B28-Dup	9/25/2007	0-15	-	-	-	-	-	-	1.8E-06	3.0E-07	-	-	-	1 E-07
RFA-B29	9/25/2007	0-15	14345	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B30A	9/26/2007	0-15	12461	-	-	-	-	-	1.8E-06	2.0E-07	-	-	-	1 E-07
RFA-B31	9/25/2007	0-15	12221	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07
RFA-B33	9/25/2007	0-15	13221	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B34	9/25/2007	0-15	13408	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B35	9/25/2007	0-15	12290	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B36A	9/25/2007	0-15	12465	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B37A	9/26/2007	0-15	11170	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07

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

Sample ID	Date Collected	Depth (cm)	Gamma Count Rate (cpm)	U-nat (μCi/g)	Pb-210 (μCi/g)	Pb-210 Error (μCi/g)	Th-230 (μCi/g)	Th-230 Error (μCi/g)	Ra-226 (μCi/g)	Ra-226 Error (μCi/g)	U-nat LLD (μCi/g)	Pb-210 LLD (μCi/g	Th-230 LLD (μCi/g)	Ra-226 LLD (μCi/g)
RFA-B38	9/25/2007	0-15	11852	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B39	9/25/2007	0-15	11478	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B40	9/25/2007	0-15	12629	5.6E-07	1.0E-06	2.0E-07	3.0E-07	1.0E-07	1.1E-06	2.0E-07	1.7E-08	1 E-07	1 E-07	1 E-07
RFA-B41	9/25/2007	0-15	11806	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B43	9/25/2007	0-15	13264	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B44	9/25/2007	0-15	11436	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
RFA-B45	9/25/2007	0-15	12242	-	-	-	-	-	1.6E-06	3.0E-07	-	-	-	1 E-07
SMA-B01	9/24/2007	0-15	10459	1.2E-06	6.0E-07	1.0E-07	5.0E-07	1.0E-07	9.0E-07	2.0E-07	1.9E-08	1 E-07	1 E-07	1 E-07
SMA-B01-Dup	9/24/2007	0-15	-	1.5E-06	2.0E-06	2.0E-07	6.0E-07	1.0E-07	1.4E-06	3.0E-07	1.8E-08	1 E-07	1 E-07	1 E-07
SMA-B03	9/24/2007	0-15	22410	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
SMA-B04	9/24/2007	0-15	15263	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
SMA-B07	9/24/2007	0-15	22925	-	-	-	-	-	3.2E-06	3.0E-07	-	-	-	1 E-07
SMA-B09	9/24/2007	0-15	12879	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
SMA-B09-Dup	9/24/2007	0-15	-	-	-	-	-	-	1.7E-06	2.0E-07	-	-	-	1 E-07
SMA-B10	9/25/2007	0-15	13184	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
SMA-B11	9/24/2007	0-15	17346	-	-	-	-	-	2.3E-06	3.0E-07	-	-	-	1 E-07
SMA-B13	9/25/2007	0-15	13252	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
SMA-B14	9/24/2007	0-15	14483	-	-	-	-	-	1.4E-06	3.0E-07	-	-	-	1 E-07
SMA-B14-Dup	9/24/2007	0-15	-	-	-	-	-	-	1.6E-06	2.0E-07	-	-	-	1 E-07
SMA-B15	9/24/2007	0-15	8474	-	-	-	-	-	8.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B16	9/24/2007	0-15	10235	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B17	9/24/2007	0-15	10139	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
SMA-B18	9/25/2007	0-15	8511	-	-	-	-	-	5.0E-07	1.0E-07	-	-	-	1 E-07
SMA-B18-Dup	9/25/2007	0-15	-	-	-	-	-	-	4.0E-07	1.0E-07	-	-	-	1 E-07
SMA-B19	9/24/2007	0-15	10074	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
SMA-B20	9/27/2007	0-15	10897	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B21	9/24/2007	0-15	16712	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
SMA-B22	9/24/2007	0-15	10618	-	-	-	-	-	8.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B23	9/24/2007	0-15	16233	-	-	-	-	-	2.7E-06	3.0E-07	-	-	-	1 E-07
SMA-B23-Dup	9/24/2007	0-15	-	-	-	-	-	-	2.8E-06	3.0E-07	-	-	-	1 E-07
SMA-B24	9/24/2007	0-15	12662	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07

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

Sample ID	Date Collected	Depth (cm)	Gamma Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
SMA-B25	9/24/2007	0-15	9991	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
SMA-B26	9/28/2007	0-15	73243	-	-	-	-	-	1.1E-05	5.0E-07	-	-	-	1 E-07
SMA-B27	9/28/2007	0-15	130293	6.7E-05	3.0E-05	8.0E-07	3.0E-05	8.0E-07	4.0E-05	1.1E-06	1.7E-08	1 E-07	1 E-07	1 E-07
SMA-B28	9/29/2007	0-15	39061	-	-	-	-	-	6.4E-06	4.0E-07	-	-	-	1 E-07
SMA-B29	9/28/2007	0-15	231041	1.6E-05	2.0E-05	7.0E-07	2.0E-05	6.0E-07	2.9E-05	9.0E-07	1.7E-08	1 E-07	1 E-07	1 E-07
SMA-B30	9/28/2007	0-15	89139	-	-	-	-	-	3.4E-05	9.0E-07	-	-	-	1 E-07
LAN 001A	7/18/2008	0-15	-	1.8E-06	2.4E-06	2.3E-06	1.2E-06	6.0E-07	8.0E-07	9.0E-08	7E-09	3.8 E-06	1 E-07	4 E-08
LAN 002A	7/18/2008	0-15	-	8.6E-07	3.4E-06	2.3E-06	9.0E-07	5.0E-07	9.0E-07	1.0E-07	7E-09	3.7 E-06	1 E-07	5 E-08
LAN 003A	7/18/2008	0-15	-	7.8E-07	8.0E-07	2.2E-06	7.0E-07	6.0E-07	1.2E-06	1.0E-07	7E-09	3.6 E-06	1 E-07	5 E-08
LAN 004A	7/18/2008	0-15	-	6.9E-07	1.0E-06	1.4E-06	6.0E-07	6.0E-07	1.9E-06	2.0E-07	7E-09	2.4 E-06	1 E-07	8 E-08
LAN 004A-DUP	7/18/2008	0-15	-	7.2E-07	5.0E-07	1.4E-06	4.0E-07	3.0E-07	7.0E-07	1.0E-07	7E-09	2.4 E-06	1 E-07	8 E-08
LAN 005A	7/18/2008	0-15	-	8.4E-07	1.2E-06	1.4E-06	9.0E-07	5.0E-07	4.4E-06	3.0E-07	7E-09	2.3 E-06	1 E-07	8 E-08
LAN 006A	7/18/2008	0-15	-	7.1E-07	-5.0E-09	1.4E-06	3.0E-07	5.0E-07	1.1E-06	1.0E-07	7E-09	2.4 E-06	1 E-07	8 E-08
LAN 007A	7/18/2008	0-15	-	8.1E-07	6.0E-07	1.4E-06	3.0E-07	5.0E-07	7.0E-07	1.0E-07	7E-09	2.4 E-06	1 E-07	8 E-08
LAN 008A	7/18/2008	0-15	-	2.1E-06	1.0E-06	1.4E-06	1.0E-06	7.0E-07	9.0E-07	1.0E-07	7E-09	2.3 E-06	1 E-07	9 E-08
LAN 009A	7/18/2008	0-15	-	1.1E-06	-4.0E-07	1.4E-06	3.0E-07	6.0E-07	8.0E-07	1.0E-07	7E-09	2.3 E-06	1 E-07	8 E-08
LAN 010A	7/18/2008	0-15	-	1.6E-06	1.8E-06	1.2E-06	1.2E-06	6.0E-07	1.2E-06	2.0E-07	7E-09	2.0 E-06	1 E-07	1 E-07
LAS 001A	7/19/2008	0-15	-	1.2E-06	1.6E-06	1.2E-06	6.0E-07	5.0E-07	9.0E-07	1.0E-07	7E-09	1.9 E-06	1 E-07	1 E-07
LAS 002A	7/19/2008	0-15	-	4.8E-07	1.4E-06	1.2E-06	1.0E-07	5.0E-07	7.0E-07	1.0E-07	7E-09	1.9 E-06	1 E-07	1 E-07
LAS 003A	7/19/2008	0-15	-	5.0E-07	1.4E-06	1.2E-06	3.0E-07	4.0E-07	7.0E-07	1.0E-07	7E-09	1.9 E-06	1 E-07	1 E-07
LAS 004A	7/19/2008	0-15	-	1.1E-06	1.2E-06	1.2E-06	6.0E-07	5.0E-07	8.0E-07	1.0E-07	7E-09	1.9 E-06	1 E-07	1 E-07
LAS 005A	7/19/2008	0-15	-	1.2E-06	1.6E-06	1.2E-06	4.0E-07	3.0E-07	9.0E-07	1.0E-07	1E-08	1.9 E-06	1 E-07	1 E-07
LAS 006A	7/19/2008	0-15	-	3.7E-07	7.0E-07	1.1E-06	6.0E-07	6.0E-07	7.0E-07	1.0E-07	7E-09	1.9 E-06	1 E-07	1 E-07
LAS 007A	7/19/2008	0-15	-	4.3E-07	6.0E-07	1.5E-06	6.0E-07	1.0E-07	8.0E-07	1.0E-07	7E-09	2.5E-06	1 E-07	9 E-08
RFA-B01B	9/26/2007	15-30	13115	1.1E-06	2.0E-06	2.0E-07	9.0E-01	2.0E-01	1.7E-06	2.0E-07	1.8E-08	1 E-07	1 E-07	1 E-07
RFA-B01B-Dup	9/26/2007	15-30	-	9.9E-07	9.0E-07	2.0E-07	9.0E-01	2.0E-01	1.5E-06	2.0E-07	1.9E-08	1 E-07	1 E-07	1 E-07
RFA-B02B	9/26/2007	15-30	-	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B13B	9/26/2007	15-30	-	-	-	-	-	-	1.8E-06	2.0E-07	-	-	-	1 E-07
RFA-B15B	9/26/2007	15-30	-	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
RFA-B17B	9/26/2007	15-30	-	-	-	-	-	-	2.2E-06	3.0E-07	-	-	-	1 E-07
RFA-B21B	9/26/2007	15-30	-	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07

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

Sample ID	Date Collected	Depth (cm)	Gamma Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
RFA-B30B	9/26/2007	15-30	-	-	-	-	-	-	2.1E-06	3.0E-07	-	-	-	1 E-07
RFA-B36B	9/26/2007	15-30	-	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B37B	9/26/2007	15-30	-	-	-	-	-	-	7.0E-07	2.0E-07	-	-	-	1 E-07
LAN 001B	7/18/2008	15-30	-	1.9E-06	4.6E-06	2.3E-06	1.4E-06	6.0E-07	8.0E-07	1.0E-07	7E-09	3.8E-06	1 E-07	4 E-08
LAN 002B	7/18/2008	15-30	-	7.5E-07	1.5E-06	2.3E-06	4.0E-07	4.0E-07	1.0E-06	1.0E-07	7E-09	3.8E-06	1 E-07	6 E-08
LAN 003B	7/18/2008	15-30	-	1.1E-06	2.4E-06	2.3E-06	8.0E-07	5.0E-07	1.2E-06	1.0E-07	7E-09	3.8E-06	1 E-07	5E-08
LAN 004B	7/18/2008	15-30	-	7.9E-07	2.2E-06	1.4E-06	2.0E-07	5.0E-07	1.3E-06	2.0E-07	7E-09	2.3E-06	1 E-07	8E-08
LAN 004B-DUP	7/18/2008	15-30	-	6.8E-07	-3.0E-07	1.4E-06	5.0E-07	4.0E-07	7.0E-07	1.0E-07	7E-09	2.3E-06	1 E-07	8E-08
LAN 005B	7/18/2008	15-30	-	7.1E-07	9.0E-07	1.4E-06	6.0E-07	4.0E-07	1.6E-06	2.0E-07	7E-09	2.4E-06	1 E-07	2E-07
LAN 006B	7/18/2008	15-30	-	7.5E-07	5.0E-07	1.4E-06	6.0E-07	4.0E-07	1.3E-06	1.0E-07	7E-09	2.3E-06	1 E-07	8E-08
LAN 007B	7/18/2008	15-30	-	1.5E-06	6.0E-07	1.4E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07	7E-09	2.4E-06	1 E-07	8E-08
LAN 008B	7/18/2008	15-30	-	3.5E-06	1.0E-07	1.4E-06	9.0E-07	7.0E-07	1.0E-06	1.0E-07	7E-09	2.3E-06	1 E-07	8E-08
LAN 009B	7/18/2008	15-30	-	1.8E-06	-3.0E-07	1.4E-06	7.0E-07	5.0E-07	4.1E-06	3.0E-07	7E-09	2.3E-06	1 E-07	8E-08
LAN 010B	7/18/2008	15-30	-	1.5E-06	1.1E-06	1.1E-06	7.9E-06	1.2E-06	1.4E-06	2.0E-07	7E-09	2.0E-06	1 E-07	1E-07
LAS 001B	7/19/2008	15-30	-	8.6E-07	1.1E-06	1.2E-06	4.0E-07	5.0E-07	8.0E-07	1.0E-07	7E-09	2.0E-06	1 E-07	1E-07
LAS 002B	7/19/2008	15-30	-	7.1E-07	7.0E-07	1.2E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1E-07
LAS 003B	7/19/2008	15-30	-	1.2E-06	1.1E-06	1.1E-06	5.0E-07	4.0E-07	9.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1E-07
LAS 004B	7/19/2008	15-30	-	9.5E-07	1.3E-06	1.2E-06	5.0E-07	4.0E-07	8.0E-07	1.0E-07	7E-09	2.0E-06	1 E-07	1E-07
LAS 005B	7/19/2008	15-30	-	1.6E-06	1.4E-06	1.1E-06	4.0E-07	4.0E-07	1.0E-06	2.0E-07	7E-09	1.9E-06	1 E-07	1E-07
LAS 006B	7/19/2008	15-30	-	4.8E-07	1.4E-06	1.2E-06	3.0E-07	4.0E-07	7.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1E-07
LAS 007B	7/19/2008	15-30	-	4.5E-07	6.0E-07	1.5E-06	6.0E-07	1.0E-07	7.0E-07	1.0E-07	7E-09	2.5E-06	1 E-07	1E-07
RFA-B01C	9/26/2007	30-100	-	1.5E-06	6.0E-07	1.0E-07	8.0E-01	1.0E-01	1.2E-06	2.0E-07	1.9E-08	1 E-07	1 E-07	1 E-07
RFA-B01C-Dup	9/29/2007	30-100	-	1.3E-06	1.0E-06	2.0E-07	1.0E+00	2.0E-01	1.7E-06	3.0E-07	1.9E-08	1 E-07	1 E-07	1 E-07
RFA-B02C	9/26/2007	30-100	-	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B13C	9/26/2007	30-100	-	-	-	-	-	-	1.6E-06	2.0E-07	-	-	-	1 E-07
RFA-B15C	9/26/2007	30-100	-	-	-	-	-	-	1.5E-06	3.0E-07	-	-	-	1 E-07
RFA-B17C	9/26/2007	30-100	-	-	-	-	-	-	2.5E-06	3.0E-07	-	-	-	1 E-07
RFA-B21C	9/26/2007	30-100	-	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B30C	9/26/2007	30-100	-	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07

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

Sample ID	Date Collected	Depth (cm)	Gamma Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
RFA-B36C	9/26/2007	30-100	-	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B37C	9/26/2007	30-100	-	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
LAN 001C	7/18/2008	30-100	-	1.9E-06	1.9E-06	2.2E-06	1.6E-06	7.0E-07	9.0E-07	1.0E-07	7E-09	3.7E-06	1 E-07	4 E-08
LAN 002C	7/18/2008	30-100	-	1.5E-06	1.1E-06	2.2E-06	3.0E-07	3.0E-07	1.2E-06	1.0E-07	7E-09	3.6E-06	1 E-07	6 E-08
LAN 003C	7/18/2008	30-100	-	2.0E-06	2.6E-06	2.3E-06	6.0E-07	3.0E-07	1.0E-06	1.0E-07	7E-09	3.7E-06	1 E-07	5 E-08
LAN 004C	7/18/2008	30-100	-	1.5E-06	8.0E-07	1.4E-06	7.0E-07	5.0E-07	1.0E-06	1.0E-07	7E-09	2.3E-06	1 E-07	8 E-08
LAN 004C-DUP	7/18/2008	30-100	-	1.3E-06	1.2E-06	1.4E-06	5.0E-07	4.0E-07	8.0E-07	1.0E-07	7E-09	2.4E-06	1 E-07	8 E-08
LAN 005C	7/18/2008	30-100	-	7.1E-07	6.0E-07	1.4E-06	5.0E-07	4.0E-07	1.5E-06	2.0E-07	7E-09	2.3E-06	1 E-07	8 E-08
LAN 006C	7/18/2008	30-100	-	1.1E-06	7.0E-07	1.4E-06	5.0E-07	3.0E-07	1.4E-06	2.0E-07	7E-09	2.4E-06	1 E-07	8 E-08
LAN 007C	7/18/2008	30-100	-	2.5E-06	1.0E-07	1.4E-06	8.0E-07	6.0E-07	4.0E-07	1.0E-07	7E-09	2.3E-06	1 E-07	8 E-08
LAN 009C	7/18/2008	30-100	-	1.6E-06	5.0E-07	1.4E-06	1.1E-06	6.0E-07	3.9E-06	3.0E-07	7E-09	2.3E-06	1 E-07	8 E-08
LAN 010C	7/18/2008	30-100	-	2.7E-06	1.9E-06	1.2E-06	1.9E-06	8.0E-07	1.5E-06	2.0E-07	7E-09	2.3E-06	1 E-07	1 E-07
LAS 001C	7/19/2008	30-100	-	6.1E-07	9.0E-07	1.1E-06	1.0E-07	3.0E-07	8.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1 E-07
LAS 002C	7/19/2008	30-100	-	6.3E-07	4.0E-07	1.1E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1 E-07
LAS 003C	7/19/2008	30-100	-	9.3E-07	7.0E-07	1.2E-06	1.0E-06	5.0E-07	8.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1 E-07
LAS 004C	7/19/2008	30-100	-	1.3E-06	1.2E-06	1.1E-06	5.0E-07	3.0E-07	9.0E-07	1.0E-07	7E-09	1.9E-06	1 E-07	1 E-07
LAS 005C	7/19/2008	30-100	-	9.8E-07	1.2E-06	1.1E-06	7.0E-07	5.0E-07	1.1E-06	2.0E-07	7E-09	1.9E-06	1 E-07	1 E-07
LAS 006C	7/19/2008	30-100	-	6.5E-07	-3.0E-07	1.5E-06	3.0E-07	9.0E-08	6.0E-07	1.0E-07	7E-09	2.6E-06	1 E-07	1 E-07
LAS 007C	7/19/2008	30-100	-	7.2E-07	-7.0E-07	1.5E-06	5.0E-07	1.0E-07	7.0E-07	1.0E-07	7E-09	2.6E-06	1 E-07	1 E-07

Notes:
All errors reported are ± 2σ

2.9.3.2.1 Surface Soil Sampling Results

The Ra-226 soil sampling results for the first set of 80 locations, the Surface Mine Area and the Main Permit Area, were analyzed with the statistical software package Minitab, version 15.1.1.0. Output from Minitab for the statistical analyses of baseline Ra-226 soil sampling results is provided in Appendix 2.9-M. The Ra-226 soil sampling results from the north section of the Main Permit Area and the Land Application Areas were not analyzed statistically.

<u>Radium-226 Concentrations in the First Set of 80 Locations</u>

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.

<u>Radium-226 Concentrations in the Surface Mine Area</u>

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.

<u>Radium-226 Concentrations in the Main Permit Area</u>

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

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

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

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

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

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

Radium-226 Concentrations in the Land Application Areas

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

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

Discussion of Radium-226 Concentrations

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

Several methods were considered to evaluate outliers, including histograms, distribution tests, and probability plots, prior to the decision to use IQRs. The set of the data from the Main Permit Area was initially found to be non-parametric (i.e., does not follow a normal, lognormal or other commonly used distribution that can be described with parameters). The IQR was used to help identify any potential outliers non-parametrically. The usefulness of using box plots to non-parametrically screen for data outliers is discussed in Chapter 12 of *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (EPA, 2009). As described on pg. 12-5 of this guidance, "Box plots…provide an alternate method to perform outlier screening, one not dependent on normality of the underlying measurement population. Instead of looking for points inconsistent with a linear pattern on a probability plot, the box plot flags as possible outliers values that are located in either or both of the *extreme tails* of the sample."

The five potential outlier locations in the data from the Surface Mine Area were biased, based on an evaluation of the gamma survey results, and were intended to capture the upper limit of radium-226 soil concentrations in the area. Because the sample locations were intentionally biased toward higher radium-226 concentrations, it is not surprising that they would be outliers compared to the remaining data set. The box plot analysis (see Figure 3 in Appendix 2.9-M) identified five samples within the Surface Mine Area as being outliers. At the request of the NRC staff, ASTM Standard E178-08, Standard Practice for Dealing with Outlying Observations (ASTM, 2002), was also used to evaluate whether the outliers identified using the box plot analysis are also outliers using the methods described within. Prior to presenting the test data contained in ASTM E178-08, three important points should be mentioned:

1) ASTM E178-08 discusses rejecting observations based on judgment provided a physical reason is known or discovered for the outlier. Statistical test for these outliers may be used but is not required to support a judgment that a physical reason actually exists for the outlier.
2) The criteria for outliers within ASTM E178-08 are based on an assumed underlying normal distribution.
3) When data are not normally or approximately normally distributed, the probabilities associated with the tests will be different (ASTM E178-08).

In the case of the five outliers in the Surface Mine Area, physical properties (the proximity of the historical open-pit uranium mines) for the higher values were known. This physical property was the reason samples were collected at these locations. Table 2.9-5a provides the statistical analysis based on methods described in Section 6 of ASTM E178-08.

Table 2.9-5a supports the decision to consider the sample results as outliers based on judgment and the outlier screening using box plots. Consistent with ASTM E178-09, these observations were recognized as likely being from a different population than the other sample values and were not used in describing the central tendency of the data or other data analysis.

Table 2.9-5a: Outlier Test for Surface Soil Samples Collected in Surface Mine Area

Potential Outlier Sample ID	Sample Ra-226 Concentration (pCi/g)	N	Mean Ra-226 Concentration (pCi/g)	Standard Deviation (pCi/g)	‡Test Statistic	†Critical Value (upper 1%)	Outlier (Yes/No)
SMA-B27	40.00	25	5.90	11.00	3.10	3.009	Yes
SMA-B30	34.00	24	4.84	8.65	3.37	2.987	Yes
SMA-B29	29.00	23	3.20	6.08	4.24	2.963	Yes
SMA-B26	11.00	22	2.02	2.36	3.81	2.939	Yes
SMA-B28	6.40	21	1.60	1.28	3.75	2.912	Yes

† Critical values obtained from Table 1 of ASTM E178-08
‡ Test Statistic $T_n = (x_n - \bar{x})/s$

Potential outliers in the data obtained in the Main Permit Area were not attributed to any known or discovered physical property. The samples were identified as potential outliers using box plots. Table 2.9-5b provides the statistical analysis for outliers for these three samples based on methods described in Section 6 of ASTM E178-08. Two of the three samples identified as outliers using box plots were also identified as outliers using the ASTM method. The outlier data in the case of the Main Permit Area are probably extreme manifestations of the random variability inherent in the data and should be retained and processed in the same manner as the other observations in the sample (ASTM E178-08). These data were only excluded from the other data processing when attempting to fit a parametric distribution to the data, in this case a lognormal distribution. These data were included when describing the median radium-226 concentration (1.3 pCi/g) for the Main Permit Area and excluded when calculating the geometric mean (1.3 pCi/g) for the same area. The estimate of the central tendency of the data using non-parametric (outliers were included in estimate) and parametric (outliers were excluded in estimate) estimates are the same.

Table 2.9-5b: Outlier Test for Surface Soil Samples Collected in Main Permit Area

Potential Outlier Sample ID	Sample Ra-226 Concentration (pCi/g)	N	Mean Ra-226 Concentration (pCi/g)	Standard Deviation (pCi/g)	‡Test Statistic	†Critical Value (upper 1%)	Outlier (Yes/No)
RFA-B21A	5.60	55	1.51	0.77	5.31	3.376	Yes
RFA-B23	3.60	54	1.44	0.54	4.00	3.368	Yes
NEA-R05	2.80	53	1.40	0.45	3.11	3.361	No

† Critical values obtained from Table 1 of ASTM E178-08
‡ Test Statistic $T_n = (x_n - \bar{x})/s$

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

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

Other Radionuclides

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

Limits of Detection

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

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

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

The LLD recommended in RG 4.14 for natural uranium, thorium-230, radium-226, and lead-210 in soils is $2*10^{-7}$ µCi/g. The only case for which the guidance was not followed was the LLD for lead-210 in the LAN and LAS samples. The median lead-210 concentration for surface soils (0-5 cm and 0-15 cm depths), excluding land application samples (LAN and LAS), was 1.5 E-6 µCi/g. In these areas, the lead-210 LLD was 1.0 E-7 µCi/g, which is consistent with the Regulatory Guide 4.14 LLD for lead-210 in soil. The median lead-210 soil concentration for surface soil in the land application areas was 1.1 E-6 µCi/g. In the land application areas, the LLD ranged from 1.9 E-6 to 3.8 E-6 µCi/g. Since the median lead-210 concentrations were similar between the two data sets, Powertech (USA) considers the reported lead-210 soil concentrations within the land application areas as representative of background regardless of the reported sample-specific LLD values.

2.9.3.2.2 Subsurface Soil Sample Results

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

2.9.3.2.3 Data Uncertainty

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

The RPD is calculated as follows:

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

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

The RER is calculated as follows:

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

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

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.

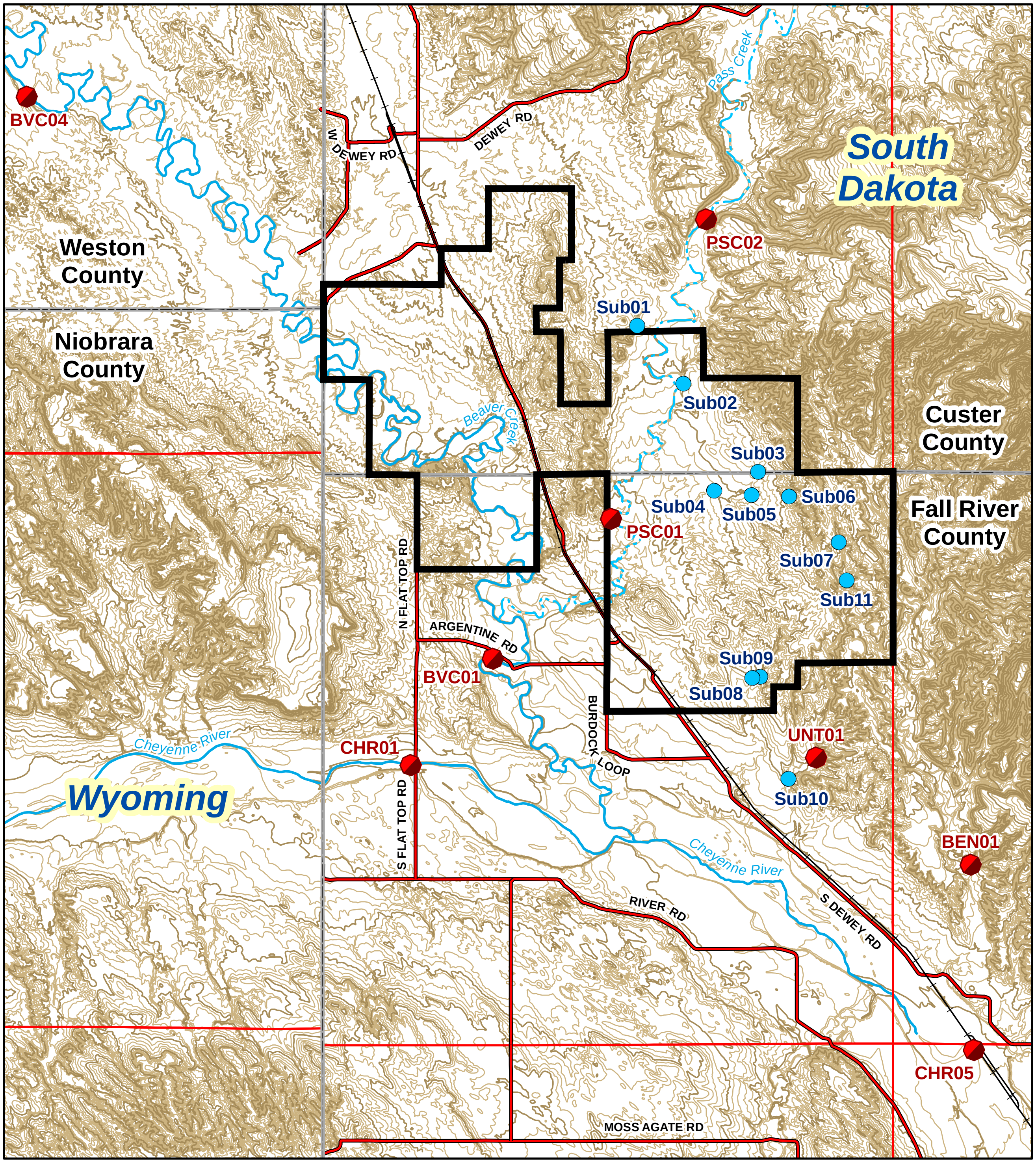
The subsurface results in both land application areas are comparable to those observed in the 0 to 15 cm surface samples in the samples. There is no apparent trend with depth.

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.



Legend

- Project Boundary
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Perennial Streams
- Stream Sampling Sites
- Impoundment Sampling Sites

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

N

Figure 2.9-11

Sediment Sampling Sites

Dewey-Burdock Project

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DATE	18-Jun-2013
FILENAME	SedimentSites.mxd

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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

Analytical results for the sediment sampling completed as part of the baseline monitoring program are provided in Appendix 2.9-H. A summary of radionuclide concentrations in sediment samples is provided in Appendix 2.9-K. The summary tables include the error and LLDs associated with each concentration in accordance with the recommendations in RG 4.14, Section 7.0. Beaver Creek sediment sample results from the historical TVA survey (TVA DES, 1980) are provided in Table 2.9-9. LLDs for radionuclide results presented in Table 2.9-9, if recorded by the laboratory during analysis, are no longer available. A FOIA request was filed with TVA, including sediment laboratory reports, but no additional information was received regarding the baseline work performed in the 1970s.

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

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

Source: TVA DES, 1980

2.9.4.3 Conclusions

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

Radionuclide concentrations in sediment at downstream locations of Pass Creek (PSC01) and the Cheyenne River (CHR05) are elevated compared to upstream locations for the same surface water bodies indicating potential impacts from mineralized areas of the on and adjacent to the site. Radionuclide concentrations in sediment at the downstream location on Beaver Creek (BVCO1) are similar to the upstream location (BVC04).

2.9.5 Ambient Gamma and Radon Monitoring

2.9.5.1 Methods

2.9.5.1.1 Ambient Gamma Dose Rate Monitoring

Ambient exposure rates were determined for three periods, using TLDs supplied and analyzed by Landauer, Inc. The monitoring periods were: August 15, 2007 to February 4, 2008, February 4 to May 17, 2008, and May 17 to July 17, 2008. The 29-day period between July 17 and August 15 that would complete the year was not monitored.

The TLDs were deployed at each of the eight AMS locations. The criteria used to establish the AMS locations is discussed in Section 2.9.6. The AMS locations meet the siting criteria recommended in Regulatory Guide 4.14. On this basis the TLD monitoring locations also meet the siting criteria recommended in Regulatory Guild 4.14. Duplicates were deployed at AMS-01 and the background location (AMS-BKG).

Five of the nine TLDs deployed in the August 2007 to February 2008 period were lost, presumably by way of cattle disturbance. Two additional TLDs were lost from subsequent deployments, presumably as a result of cattle in the area.

2.9.5.1.2 Ambient Radon-222 Monitoring

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

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

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

2.9.5.2 Results

2.9.5.2.1 Ambient Gamma Dose Rate Monitoring

The ambient gamma dose rate monitoring results are listed in Table 2.9-10. All reported dose equivalents were converted to an adjusted dose rate by dividing by the time between the shipment of the dosimeters to the site and the time that the dosimeters were processed by the vendor. In order to obtain an estimate of the annual dose equivalent rate, the average daily dose rate for the 29-day period (July 17, 2008-August 15, 2008) which was not monitored was assumed equal to the May 17, 2008 to July 17, 2008 period. This is reasonable since terrestrial dose rates for a location primarily depend on soil moisture and snow and vegetation cover. For locations where TLDs were missing, no attempt was made to obtain an annual projected dose equivalent. The results for the TLDs reported in millirem per year (mrem/yr) ambient dose equivalents are as follows:

- AMS-04: 112 mrem/yr
- AMS-05: 91 mrem/yr
- AMS-07: 109 mrem/yr
- AMS-BKG: 123 mrem/yr

The TLD results compare favorably with the baseline direct gamma-ray survey data for the site reported in Section 2.9.2.1.1 when expressed in exposure rate units (μR/h) as reported in Section 2.9.2.2.2, where the average exposure rate was reported as 10.9 microRoentgen/h (μR/h). Since a Roentgen is approximately equal to a rem, 10.9 μR/h can be expressed as 96 mrem/yr. This is very close to the 109 mrem/y average for the four monitoring locations.

The range of exposure rates (91 to 123 mrem/yr) and average (109 mrem/yr) are similar to average worldwide exposures to natural radiation sources comprised of cosmic radiation, cosmogenic radionuclides, and external terrestrial radiation reported in the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex. The typical ranges of average worldwide exposures reported in this reference document are from 60 to 160 mrem/yr.

The analytical reports are provided as Appendix 2.9-C. Included at the beginning of Appendix 2.9-C is an index sheet listing the TLD reports by sample location and monitoring period.

TLDs at the stations AMS-01, AMS-02, AMS-03, and AMS-06 were eaten or otherwise removed by cattle or humans for one or more of the monitoring periods. For example, Table 2.9-10 shows that the TLD monitoring period for AMS-01 was 164 days. The documentation for the monitoring periods for each AMS is included in Appendix 2.9-C. Rather than computing an annual average dose equivalent rate for these stations, Powertech (USA) relied on the extensive set of exposure rate data predicted from the GPS-based gamma surveys. The gamma-ray count rates were converted to exposure rates by developing a correlation with data from a pressurized ionization chamber (PIC). As described above, the annual gamma dose rate for the project area (96 mrem) agrees well with the 109 mrem annual measured dose equivalent rate from the TLD data at the four monitoring stations where the data sets are complete. These stations are located to the north, southwest, and south of the project area, not near the historical surface mining area or other known elevated exposure rate anomalies.

Table 2.9-10: Ambient Gamma Dose Rates

Location	Starting Date	End Date	Dose (mrem)	Adjusted Dose Rate (mrem/day)[b]	Projected Annual Doses (mrem)
AMS-01	8/15/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	37.2[a]	0.260	
	5/17/08	7/17/08	57.7[a]	0.412	
AMS-02	8/16/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	-	NC	
	5/17/08	7/17/08	54.0	0.386	
AMS-03	8/15/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	38.6	0.270	
	5/17/08	7/17/08		NC	
AMS-04	8/15/07	2/4/08	62.4	0.297	112
	2/4/08	5/17/08	36.1	0.252	
	5/17/08	7/17/08	54.3	0.388	
AMS-05	8/15/07	2/4/08	50.6	0.241	91
	2/4/08	5/17/08	36.7	0.257	
	5/17/08	7/17/08	36.4	0.260	
AMS-06	8/15/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	36.9	0.258	
	5/17/08	7/17/08	51.1	0.365	
AMS-07	8/15/07	2/4/08	73.7	0.351	109
	2/4/08	5/17/08	35.5	0.248	
	5/17/08	7/17/08	36.1	0.258	
AMS-BKG	8/15/07	2/4/08	68.8[a]	0.328	123
	2/4/08	5/17/08	40.5[a]	0.283	
	5/17/08	7/17/08	58.5[a]	0.418	

Notes:

a. Result is average of measurement plus duplicate.
b. Dose rate adjusted by dividing the reported dose by the time from vendor shipment of dosimeters to site and the time dosimeters were processed.

NC = Not Calculated due to missing data

2.9.5.2.2 Ambient Radon-222 Monitoring

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

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Table 2.9-11: Radon Concentrations in Air

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

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

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

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

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

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

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

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

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

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

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

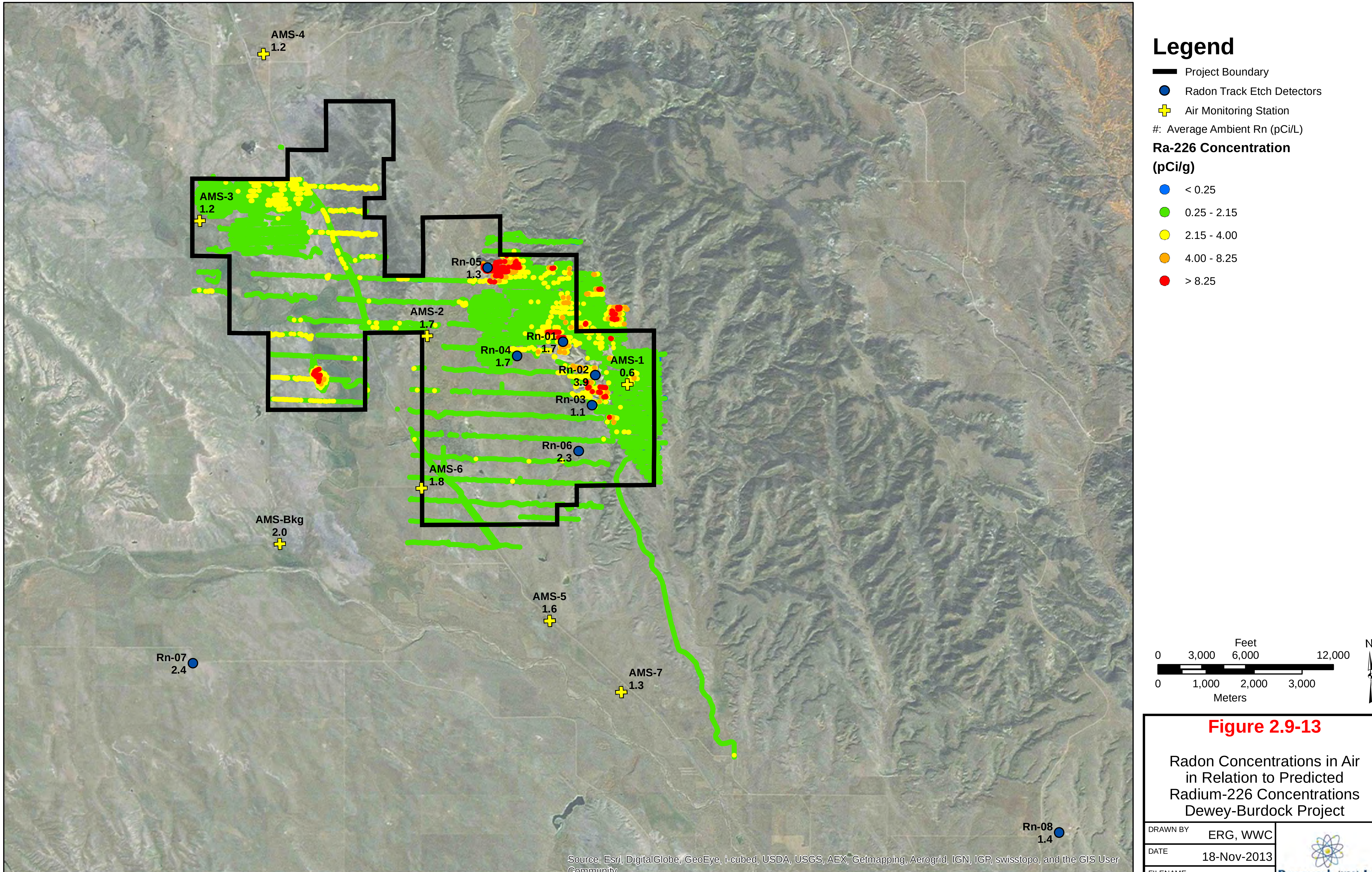

Figure 2.9-13

Radon Concentrations in Air in Relation to Predicted Radium-226 Concentrations Dewey-Burdock Project

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Powertech (USA) Inc.

2.9.5.3 Conclusions

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

2.9.6 Air Particulate Monitoring

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

2.9.6.1 Methods

Eight Hi-Q Model HVP-4200AFC high volume air samplers were established within and surrounding the proposed permit area. The samplers operated continuously for 366 days from August 2007 to August 2008 except for minor down time due to filter changes, power outages, and other disruptions of the power supply. This was consistent with the recommendations in RG 4.14 and requirements in 10 CFR 40, Appendix A, Criterion 7. The locations of the air samplers are shown on Figures 2.9-8 and 2.9-13.

The criteria used to establish air particulate sampling locations include the following factors:

1) Average meteorological conditions such as wind speed, wind direction and atmospheric stability
2) Prevailing wind direction
3) Site boundaries nearest to proposed facility processing areas, land application areas, and well fields
4) Direction of nearest occupiable structure
5) Locations of estimated maximum concentrations of radioactive materials
6) Locations of existing features near or within the proposed license boundary, but unrelated to proposed site activities, that may impact background radiological conditions (e.g., railroads and historical surface mines)
7) Location of nearest multiple resident area or town

Factors 1-5 are identical to the air particulate sampler siting criteria contained in Regulatory Guide 4.14. Factors 6 and 7 were added to account for site-specific conditions. Table 2.9-11a compares the air monitoring station locations suggested by Regulatory Guide 4.14 to those established for the site. The locations of the air monitoring stations are shown on Figure 2.9-8. Figure 2.9-14 shows the Dewey-Burdock wind direction distribution.

Table 2.9-11a: Regulatory Guide 4.14 Recommended Versus Pre-operational Air Monitoring Locations

Regulatory Guide 4.14 Recommendation	Dewey-Burdock Pre-operational Monitoring Locations
Three locations at or near the site boundary	Initially, AMS-01 was positioned to evaluate particulate emissions potentially resulting from disturbed areas associated with historical open-pit uranium mines to the west and northwest of this location. AMS-01 is also near the eastern boundary of the project area, approximately 3.2 km east-southeast of the proposed Burdock land application areas. Figure 2.9-8 shows the location of AMS-01 relative to the Burdock land application areas. This figure also shows the predominant wind directions and the wind rose. The land application areas are the only expected source of potential routine airborne particulate emissions in the form of long-lived radionuclides. Winds from the northwest occur nearly 20% of the time as shown in Figure 2.9-14. Additionally, the strongest winds are from the northwest as shown on the updated wind rose. AMS-01 is positioned near the eastern boundary of the project area and downwind from the only potential source of routine airborne particulate radionuclide emissions. Using the factors listed above, AMS-01 meets the criteria to establish an air particulate sampling location at this boundary location.
	AMS-02 is near the project boundary in the center of the project area. It is approximately 3.5 km east-southeast of the proposed Satellite Facility and 2.5 km northwest of the proposed CPP. Winds from the southeast (including east-southeast and south-southeast) occur approximately 15% of the time as shown in Figure 2.9-14. Winds from the northwest (including north-northwest and west–northwest) occur approximately 40% of the time. Additionally, the strongest winds are from the northwest as shown on the wind rose. AMS-02 is positioned in downwind direction from the proposed Satellite Facility and CPP. This is an ideal location to monitor potential airborne particulate radionuclide emissions from all potential facility-related sources.
	AMS-03 is near the northwest project boundary. It is approximately 2 km west of the proposed Satellite Facility and very near the Dewey land application areas. Winds from the east occur approximately 8% of the time, which is the fourth highest frequency when compared to other sectors from the 16 compass directions (refer to Figure 2.9-14). Given the proximity of AMS-03 to the proposed Satellite Facility and the Dewey land application areas and the significant contribution of winds from the east and east-southeast, AMS-03 is ideally located to evaluate potential environmental impacts of airborne particulate radionuclide emissions.

Table 2.9-11a: Regulatory Guide 4.14 Recommended Versus Pre-operational Air Monitoring Locations (Continued)

Regulatory Guide 4.14 Recommendation	Dewey-Burdock Pre-operational Monitoring Locations
If within 10 km of the site, an air sampler should be at or near the structure with the highest predicted airborne radionuclide concentration due to milling operations and at or near at least one structure in any area where predicted doses exceed 5% of the standards in 40 CFR Part 190.	Location AMS-02 is located within 10 km of the site, is adjacent to occupiable structures and is downwind of the CPP and Satellite Facility and land application areas. AMS-02 has the highest predicted airborne radionuclide concentrations during ISR operations for locations with occupiable structures in and around the project area, as determined by MILDOS-AREA.
A remote location that represents background conditions at the mill site.	AMS-BKG is approximately 7 km south of the proposed Satellite Facility and 6 km east-southeast of the proposed CPP. AMS-BKG is in one of the least prevalent wind directions from both the proposed Satellite Facility and the CPP. It is expected that this location would be unaffected by the proposed uranium recovery operations.

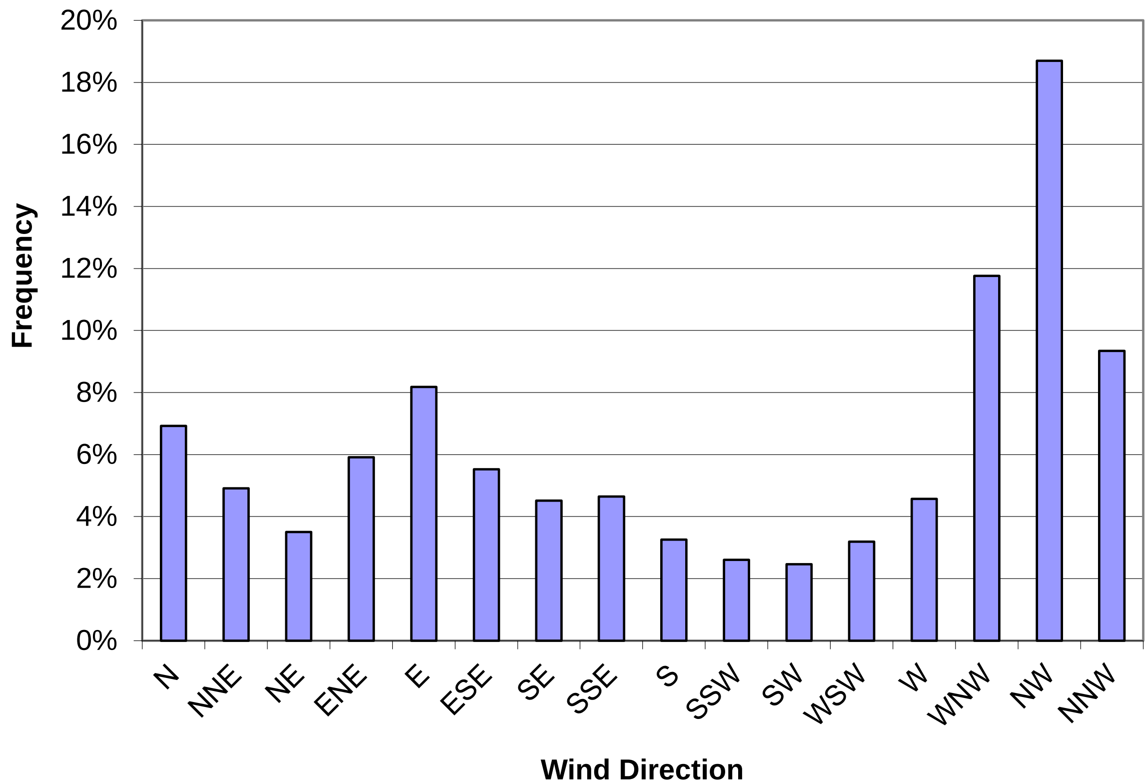

Figure 2.9-14: Dewey-Burdock Wind Direction Distribution

Table 2.9-11b shows the sum of predicted particulate radionuclide concentrations in air for all of the AMS locations and the southeast corner of the project boundary. The southeast corner of the project boundary was included in this evaluation in response to an NRC staff question regarding the absence of a pre-operational air particulate sampler at this location, which is in the downwind direction from the CPP. The predicted airborne radionuclide concentrations were obtained from the MILDOS-AREA output contained in Appendix 7.3-A. As shown in Table 2.9-11b, AMS-02 has the highest predicted airborne radionuclide concentrations of the air monitoring locations followed by AMS-03 and AMS-01. Based on the April 7-8, 2011 meeting with NRC staff, Powertech (USA) understands that NRC staff do not disagree that AMS-02 and AMS-03 are acceptable boundary locations according to Regulatory Guide 4.14 recommendations. Additionally, the predicted air concentrations at AMS-01 are similar to the predicted airborne radionuclide concentrations at AMS-03 and are larger than the predicted airborne radionuclide concentrations at the southeast corner of the project boundary. Based on the provided information and supported by the updated annual wind rose shown in Figure 2.9-8, AMS-01 also meets the siting criteria contained in Regulatory Guide 4.14.

Four stations were initially sited consistent with factor 6 listed above. These included Stations AMS-01, AMS-05, AMS-06 and AMS-07. AMS-04 was placed in the town of Dewey because this is the closest area to the proposed license boundary that contains multiple residences. As discussed above, AMS-01 also meets the siting criteria contained in Regulatory Guide 4.14 for a site boundary monitoring location.

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

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

Table 2.9-11b: Predicted Airborne Radionuclide Concentrations at Dewey-Burdock AMS Locations

Location	U-nat (µCi/ml)	Th-230 (µCi/ml)	Ra-226 (µCi/ml)	Pb-210 (µCi/ml)	Total Concentration (µCi/ml)
AMS-02	1.18E-15	3.95E-16	2.37E-16	3.94E-17	1.86E-15
AMS-03	5.14E-16	1.71E-16	1.03E-16	1.71E-17	8.05E-16
AMS-01	4.67E-16	1.56E-16	9.35E-17	1.56E-17	7.32E-16
AMS-06	2.15E-16	7.18E-17	4.31E-17	7.17E-18	3.37E-16
AMS-04	1.46E-16	4.88E-17	2.93E-17	4.87E-18	2.29E-16
AMS-05	1.34E-16	4.45E-17	2.67E-17	4.44E-18	2.09E-16
AMS-07	1.03E-16	3.44E-17	2.06E-17	3.43E-18	1.62E-16
AMS-BKG	8.83E-17	2.95E-17	1.77E-17	2.94E-18	1.38E-16
Southeast Boundary	3.42E-16	1.14E-16	6.84E-17	1.14E-17	5.35E-16

µCi/ml = microCuries per milliliter

Based on the use of modern, automatic flow control air samplers, the recommendation in Regulatory Guide 4.14 to change filters weekly is obsolete. When Regulatory Guide 4.14 was issued, automatic flow control air samplers were not available, resulting in the need for weekly filter changes. Use of automatic flow control air samplers and visual observations and flows recorded during each filter change confirmed that bi-weekly filter changes were sufficiently frequent to prevent any reduction in performance due to dust loading.

The approximately bi-weekly filter collection schedule was chosen based on the following:

1) As part of the baseline monitoring program, Powertech (USA) utilized brushless, automatic flow control hi-vol air samplers. Each air sampler was equipped with a variable speed motor, controlled by a programmable logic controller (PLC). The PLC received input from a mass air flow sensor placed in the air flow path downstream of the filter paper. Any changes in the pre-set flow rate due to dust loading, barometric pressure or temperature were detected by the air flow sensor and the PLC compensated by adjusting the motor speed to maintain the pre-set flow rate.

2) Each air sampler was equipped with an air flow totalizer, which was recorded and reset during each filter change.

3) Given the rural South Dakota site location and the features of the samplers described above, it was unlikely that total suspended particulate concentrations in air would interfere with air flow rates over a two-week period.

Air Particulate Sampler Calibration Methods

The model number of the high-volume, air particulate samplers used during baseline monitoring for the Dewey-Burdock Project was HVP-4200AFC. The unit is manufactured by Hi-Q Environmental Products Company, San Diego, CA. The procedures to operate and maintain this equipment are described in the manufacturer's operations and maintenance manual (Hi-Q, 2006), which is included as Appendix 2.9-B. The samplers were purchased new from the manufacturer and deployed on or near August 13, 2007. Although the operations and maintenance manual states that the units were calibrated before leaving the factory and there was no need to calibrate before use, a calibration check was performed after initial installation using the procedures described in the operations and maintenance manual. The operations and maintenance manual also states that all air flow devices should be recalibrated at least once a year against a traceable standard. Since air monitoring was discontinued on August 13, 2008, one year after installation, recalibration was not deemed necessary.

The air particulate samplers were equipped with air flow totalizers, which were recorded and reset during each filter change. Qualitative checks of air particulate sampler operation were also performed during each filter change. No anomalous flow volumes or conditions were observed.

Sample Analysis and Calculation of Results

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

Uranium in air particulate was reported by the laboratory in milligrams per filter composite. The results for uranium were converted to microcuries per milliliter using the specific activity for natural uranium provided in Footnote 3 to 10 CFR Part 20, Appendix B and the following equation:

$$[U_{nat}] = \frac{U_{nat}\text{Result (mg)} \times SA_{unat}(\text{Ci/g}) * 1\text{x}10^6 \ \mu\text{Ci/Ci}}{1000 \text{ mg/g} * V \text{ (ml)}}$$

Where:

$[U_{nat}]$ = Air concentration of natural uranium (µCi/ml)

SA_{unat} = Specific activity of natural uranium (6.77 E-7 Ci/g)

U_{nat} Result = Laboratory result for natural uranium in filter composite (mg)

V = Volume of air sampled (ml)

For the parameters other than natural uranium, the data were converted to units of microcuries per milliliter (µCi/ml), as follows:

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

The units of total flow and filter concentration in the equation are cubic meters and pCi/f, respectively. The resulting concentrations for each radionuclide and high volume sampler were compared to effluent concentration limits listed in Table 2 of 10 CFR 20 Appendix B and reported in Table 2.9-12 as percentages of the respective effluent limits. The most conservative effluent limits were applied to thorium-230 ($2*10^{-14}$ µCi/ml) and lead-210 ($6*10^{-13}$ µCi/ml). The Class D and W limits were applied to natural uranium ($3*10^{-12}$ µCi/ml) and radium-226 ($9*10^{-13}$ µCi/ml), respectively.

2.9.6.2 Air Particulate Sampling Results

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

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

- Natural uranium concentrations ranged from $-3.0*10^{-17}$ to $1.5*10^{-14}$ µCi/ml and averaged $1.4*10^{-15}$ µCi/ml.
- Thorium-230 concentrations ranged from $-1.5*10^{-18}$ to $5.6*10^{-17}$ µCi/ml and averaged $1.2*10^{-17}$ µCi/ml.
- Radium-226 concentrations ranged from $-4.9*10^{-17}$ to $5.3*10^{-17}$ µCi/ml and averaged $1.6*10^{-18}$ µCi/ml.
- Lead-210 concentrations ranged from $6.0*10^{-15}$ to $4.1*10^{-14}$ µCi/ml and averaged $1.5*10^{-14}$ µCi/ml.

There are no clear patterns in the data, in terms of radionuclide concentrations, when evaluating them spatially or temporally. Average natural uranium concentrations at each location were on the order of 10^{-15} µCi/ml over the course of monitoring. Thorium-230 concentrations fluctuated between the orders of 10^{-17} and 10^{-18} µCi/ml. Radium-226 concentrations fluctuated

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

Table 2.9-12: Radionuclide Concentrations in Air

Location	Period	Concentration (µCi/ml)							% of Effluent Concentration				Lower Limit of Detection (µCi/ml)			
		U-nat	Th-230	Th-230 2σ Error	Ra-226	Ra-226 2σ Error	Pb-210	Pb-210 2σ Error	U-nat	Th-230	Ra-226	Pb-210	U-nat	Th-230	Ra-226	Pb-210
AMS-01	1	7.10E-15	1.70E-17	2.80E-17	5.30E-17	4.30E-17	2.40E-14	6.20E-16	0.24%	0.00%	0.01%	4.00%	7.10E-15	4.20E-18	4.80E-17	2.10E-17
	2	0.00E+00	1.60E-18	1.10E-17	7.20E-18	9.10E-18	4.10E-14	6.90E-16	0.00%	0.00%	0.00%	6.78%	1.60E-16	1.60E-18	1.60E-18	7.90E-18
	3	-1.30E-17	3.40E-18	1.00E-17	1.80E-17	1.70E-17	2.10E-14	3.50E-16	0.00%	0.00%	0.00%	3.54%	1.70E-18	1.70E-18	1.20E-17	2.10E-16
	4	2.40E-17	1.30E-17	9.80E-18	1.40E-17	9.70E-18	2.10E-14	4.90E-16	0.00%	0.00%	0.00%	3.51%	1.50E-18	1.50E-18	8.30E-18	4.20E-16
	5	-1.70E-17	6.50E-18	2.50E-17	-3.10E-17	2.70E-17	1.00E-14	6.50E-16	0.00%	0.00%	0.00%	1.74%	4.30E-18	4.30E-18	5.60E-17	6.70E-16
AMS-02	1	7.00E-15	4.10E-18	2.80E-17	-8.30E-18	2.90E-17	1.10E-14	4.50E-16	0.23%	0.00%	0.00%	1.85%	7.00E-15	4.10E-18	3.70E-17	2.10E-17
	2	0.00E+00	1.60E-17	1.10E-17	-2.30E-18	7.00E-18	2.00E-14	4.70E-16	0.00%	0.00%	0.00%	3.26%	1.50E-16	1.50E-18	1.50E-18	7.60E-18
	3	-2.00E-17	4.70E-18	1.10E-17	-8.60E-18	1.30E-17	8.90E-15	2.50E-16	0.00%	0.00%	0.00%	1.49%	1.60E-18	1.60E-18	1.10E-17	1.90E-16
	4	4.20E-18	0.00E+00	7.40E-18	-4.20E-18	7.40E-18	8.20E-15	4.20E-16	0.00%	0.00%	0.00%	1.37%	1.40E-18	1.40E-18	7.60E-18	3.90E-16
	5	-1.30E-17	0.00E+00	8.00E-18	-4.90E-17	2.30E-17	1.50E-14	6.50E-16	0.00%	0.00%	0.00%	2.44%	4.00E-18	4.00E-18	5.30E-17	6.20E-16
AMS-03	1	5.00E-15	-1.50E-18	2.00E-17	-5.90E-18	2.10E-17	1.20E-14	3.70E-16	0.17%	0.00%	0.00%	1.97%	5.00E-15	3.00E-18	2.70E-17	1.50E-17
	2	0.00E+00	9.30E-18	1.00E-17	5.40E-18	8.90E-18	1.30E-14	3.90E-16	0.00%	0.00%	0.00%	2.16%	1.60E-16	1.60E-18	1.60E-18	7.80E-18
	3	-3.00E-17	9.30E-18	1.20E-17	-1.40E-17	1.30E-17	9.20E-15	2.50E-16	0.00%	0.00%	0.00%	1.53%	1.50E-18	1.50E-18	1.20E-17	1.90E-16
	4	1.80E-17	8.90E-18	9.00E-18	9.60E-18	9.50E-18	8.00E-15	4.40E-16	0.00%	0.00%	0.00%	1.34%	1.50E-18	1.50E-18	8.90E-18	4.10E-16
	5	-1.60E-17	1.90E-17	9.70E-18	-3.20E-18	3.10E-17	1.20E-14	6.50E-16	0.00%	0.00%	0.00%	1.99%	4.20E-18	4.20E-18	5.00E-17	6.60E-16
AMS-04	1	5.00E-15	5.90E-18	2.50E-17	4.60E-17	2.90E-17	1.10E-14	3.70E-16	0.17%	0.00%	0.01%	1.89%	5.00E-15	3.00E-18	3.00E-17	1.50E-17
	2	0.00E+00	9.40E-18	1.10E-17	2.30E-18	8.30E-18	2.20E-14	5.10E-16	0.00%	0.00%	0.00%	3.66%	1.60E-16	1.60E-18	1.60E-18	7.80E-18
	3	-2.60E-17	2.50E-18	1.10E-17	-2.80E-17	1.20E-17	8.50E-15	2.60E-16	0.00%	0.00%	0.00%	1.42%	1.70E-18	1.70E-18	9.90E-18	2.00E-16
	4	1.90E-17	6.60E-18	9.00E-18	1.20E-17	9.50E-18	1.00E-14	4.60E-16	0.00%	0.00%	0.00%	1.74%	1.50E-18	1.50E-18	8.10E-18	4.10E-16
	5	-1.00E-18	2.70E-17	9.70E-18	-5.20E-18	3.30E-17	1.30E-14	6.70E-16	0.00%	0.00%	0.00%	2.23%	4.20E-18	4.20E-18	5.50E-17	6.60E-16

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

Location	Period	Concentration (µCi/ml)							% of Effluent Concentration				Lower Limit of Detection (µCi/ml)			
		U-nat	Th-230	Th-230 2σ Error	Ra-226	Ra-226 2σ Error	Pb-210	Pb-210 2σ Error	U-nat	Th-230	Ra-226	Pb-210	U-nat	Th-230	Ra-226	Pb-210
AMS-05	1	5.90E-15	2.60E-17	2.50E-17	-4.50E-17	2.40E-17	1.10E-14	5.30E-16	0.20%	0.00%	0.00%	1.82%	5.90E-15	3.50E-18	4.50E-17	1.70E-17
	2	0.00E+00	2.00E-17	1.40E-17	4.70E-17	1.30E-17	2.50E-14	2.60E-16	0.00%	0.00%	0.01%	4.09%	1.60E-16	1.50E-18	1.50E-18	7.70E-18
	3	1.00E-18	4.70E-18	1.10E-17	1.10E-17	1.50E-17	1.00E-14	4.40E-16	0.00%	0.00%	0.00%	1.66%	1.60E-18	1.60E-18	1.10E-17	1.90E-16
	4	2.50E-17	1.30E-17	9.20E-18	1.30E-17	9.00E-18	1.00E-14	6.30E-16	0.00%	0.00%	0.00%	1.74%	1.40E-18	1.40E-18	7.70E-18	3.90E-16
	5	2.40E-17	5.60E-17	9.50E-18	2.20E-17	3.40E-17	1.10E-14	0.00E+00	0.00%	0.00%	0.00%	1.85%	4.10E-18	4.10E-18	4.90E-17	6.40E-16
AMS-06	1	5.0E-15	1.5E-18	2.0E-17	-3.9E-17	1.8E-17	1.4E-14	4.0E-16	0.17%	0.00%	0.00%	2.28%	5.0E-15	3.0E-18	3.1E-17	1.5E-17
	2	0.0E+00	1.4E-17	1.2E-17	2.3E-17	1.0E-17	2.1E-14	4.8E-16	0.00%	0.00%	0.00%	3.56%	1.5E-16	3.0E-18	1.5E-18	7.3E-18
	3	-1.4E-17	9.4E-18	1.2E-17	0.0E+00	1.4E-17	6.0E-15	2.2E-16	0.00%	0.00%	0.00%	0.99%	1.6E-18	3.0E-18	1.1E-17	1.9E-16
	4	1.5E-17	4.9E-18	9.1E-18	-4.9E-18	7.4E-18	9.5E-15	4.3E-16	0.00%	0.00%	0.00%	1.58%	1.4E-18	3.0E-18	8.3E-18	3.9E-16
	5	-2.6E-18	2.0E-17	9.1E-18	6.9E-18	3.3E-17	1.9E-14	6.9E-16	0.00%	0.00%	0.00%	3.25%	4.0E-18	3.0E-18	4.9E-17	6.2E-16
AMS-07	1	1.5E-14	2.0E-17	2.1E-17	-4.3E-18	2.5E-17	1.8E-14	4.4E-16	0.51%	0.00%	0.00%	3.03%	4.8E-15	2.8E-18	3.4E-17	1.4E-17
	2	0.0E+00	1.3E-17	1.2E-17	2.9E-17	1.0E-17	2.8E-14	5.3E-16	0.00%	0.00%	0.00%	4.62%	1.4E-16	1.4E-18	1.4E-18	6.9E-18
	3	-1.1E-17	6.3E-18	9.0E-18	-1.3E-17	1.1E-17	7.2E-15	2.2E-16	0.00%	0.00%	0.00%	1.19%	1.4E-18	1.4E-18	9.1E-18	1.7E-16
	4	2.0E-17	7.9E-18	8.1E-18	-6.6E-19	7.5E-18	1.3E-14	4.4E-16	0.00%	0.00%	0.00%	2.13%	1.3E-18	1.3E-18	7.3E-18	3.7E-16
	5	-9.2E-19	1.7E-17	8.5E-18	1.4E-17	3.0E-17	1.3E-14	5.9E-16	0.00%	0.00%	0.00%	2.10%	3.7E-18	3.7E-18	4.6E-17	5.8E-16
AMS-BKG	1	5.7E-15	3.0E-17	2.6E-17	5.0E-18	3.1E-17	1.4E-14	4.2E-16	0.19%	0.00%	0.00%	2.26%	5.7E-15	3.3E-18	4.0E-17	1.7E-17
	2	0.0E+00	-7.8E-19	9.4E-18	1.2E-17	9.5E-18	2.0E-14	4.8E-16	0.00%	0.00%	0.00%	3.29%	1.6E-16	1.6E-18	1.6E-18	7.8E-18
	3	1.6E-18	2.0E-17	1.3E-17	-5.6E-18	1.4E-17	8.3E-15	2.5E-16	0.00%	0.00%	0.00%	1.38%	1.6E-18	1.6E-18	1.2E-17	2.0E-16
	4	1.5E-17	1.4E-18	8.6E-18	2.1E-18	8.0E-18	1.3E-14	4.6E-16	0.00%	0.00%	0.00%	2.13%	1.4E-18	1.4E-18	8.5E-18	4.0E-16
	5	-8.1E-18	2.4E-17	9.3E-18	-1.7E-17	2.4E-17	1.2E-14	6.3E-16	0.00%	0.00%	0.00%	2.00%	4.0E-18	4.0E-18	4.0E-17	6.3E-16

Notes: The laboratory reported no blank assay data for Period 5. Blank assays in the sample concentration calculation were assumed to be 50 percent of the values for blanks reported for the previous period. The assumption is based on the relative, approximate run-time of the air samplers in both periods. No blank corrections were performed on uranium results for the first monitoring period since sample results were reported as non-detects.

Table 2.9-13: Summary of Radionuclide Concentrations in Air

Location	U-nat Concentration (µCi/ml)				Th-230 Concentration (µCi/ml)				Ra-226 Concentration (µCi/ml)				Pb-210 Concentration (µCi/ml)			
	Average	σ	Min	Max	Average	σ	Min	Max	Average	σ	Min	Max	Average	σ	Min	Max
AMS-01	1.4E-15	3.2E-15	-1.7E-17	7.1E-15	8.2E-18	6.4E-18	1.6E-18	1.7E-17	1.2E-17	3.0E-17	-3.1E-17	5.3E-17	2.3E-14	1.4E-17	9.1E-18	4.3E-17
AMS-02	1.4E-15	3.1E-15	-2.0E-17	7.0E-15	4.9E-18	6.5E-18	0.0E+00	1.6E-17	-1.4E-17	1.9E-17	-4.9E-17	-2.3E-18	1.3E-14	9.7E-18	7.0E-18	2.9E-17
AMS-03	1.0E-15	2.2E-15	-3.0E-17	5.0E-15	9.0E-18	7.2E-18	-1.5E-18	1.9E-17	-1.6E-18	9.3E-18	-1.4E-17	9.6E-18	1.1E-14	9.2E-18	8.9E-18	3.1E-17
AMS-04	1.0E-15	2.2E-15	-2.6E-17	5.0E-15	1.0E-17	9.8E-18	2.5E-18	2.7E-17	5.3E-18	2.7E-17	-2.8E-17	4.6E-17	1.3E-14	1.1E-17	8.3E-18	3.3E-17
AMS-05	1.2E-15	2.6E-15	0.0E+00	5.9E-15	2.4E-17	1.9E-17	4.7E-18	5.6E-17	9.6E-18	3.4E-17	-4.5E-17	4.7E-17	1.3E-14	1.0E-17	9.0E-18	3.4E-17
AMS-06	1.0E-15	2.3E-15	-1.4E-17	5.0E-15	9.9E-18	7.2E-18	1.5E-18	2.0E-17	-2.6E-18	2.3E-17	-3.9E-17	2.3E-17	1.4E-14	9.9E-18	7.4E-18	3.3E-17
AMS-07	3.1E-15	6.9E-15	-1.1E-17	1.5E-14	1.3E-17	5.7E-18	6.3E-18	2.0E-17	4.9E-18	1.7E-17	-1.3E-17	2.9E-17	1.6E-14	1.0E-17	7.5E-18	3.0E-17
AMS-BKG	1.1E-15	2.5E-15	-8.1E-18	5.7E-15	1.5E-17	1.4E-17	-7.8E-19	3.0E-17	-6.3E-19	1.1E-17	-1.7E-17	1.2E-17	1.3E-14	9.8E-18	8.0E-18	3.1E-17
Overall	1.4E-15		-3.0E-17	1.5E-14	1.2E-17		1.5E-18	5.6E-17	1.6E-18		-4.9E-17	5.3E-17	1.45E-14		7.0E-18	4.3E-17

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

- Natural uranium concentrations were 0.0 to 0.5 percent of its effluent concentration.
- Thorium-230 concentrations were 0.0 percent of its effluent concentration.
- Radium-226 concentrations were -0.0 to 0.01 percent of its effluent concentration.
- Lead-210 concentrations were 1.0 to 6.8 percent of its effluent concentration.

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

Justification is provided below for U-nat LLD values for monitoring periods 1 and 2 that do not satisfy Regulatory Guide 4.14 guidance. U-nat LLD values met the Regulatory Guide 4.14 guidance for all other monitoring periods, and LLDs for all other radionuclide concentrations in air met the Regulatory Guide 4.14 guidance for all monitoring periods.

U-nat LLD values greater than the Regulatory Guide 4.14 guidance can be justified by the use of the data, both currently and in the future. Currently the data are used to establish the pre-operational baseline condition of the airborne radionuclide concentrations in and around the project area. NUREG/CR-4007 states that "any measurement process must be capable of detecting the relevant radionuclides at levels well below those of concern to the public health and safety" (NRC, 1984). Regulatory Guide 4.14 states that one of its recommended siting criteria is to place an air particulate monitoring station at or near a structure with the highest predicted airborne radionuclide concentration due to milling operations and at or near at least one structure in any area where predicted doses exceed 5 percent of the standards in 40 CFR Part 190. A dose level of 5 percent of the standards in 40 CFR Part 190 is interpreted as being "well below those of concern to the public health and safety." On this basis, an LLD for air particulate monitoring low enough to measure an airborne radionuclide concentration that would result in at least 5 percent of the standards in 40 CFR 190 is justified.

The dose standards in 40 CFR 190 are an annual dose equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public as result of planned discharges of radioactive materials, radon and radon decay products excepted. For inhalation of natural uranium, the annual dose equivalent of 25 mrem to other organs of the body (the bone surface in the case of natural uranium) is the most restrictive limit. Equations 2.3 and 2.4 were used to determine the concentration of natural uranium in air that would result in an annual dose equivalent of 1.25 mrem (5 percent of the standard) to a member of the public. The inhalation dose conversion factor (DCF) from Federal Guidance 11 (EPA, 1988) for Class D U-234 with the target organ of the bone surface was used, since it is the most restrictive of the three lung clearance classes for the three uranium isotopes contained in natural uranium.

$$C_{U-nat} = 1.25\ (mrem)\ x\ \frac{1}{DCF\ x\ BR\ x\ T x\ FO} \qquad \text{(Equation 2.3)}$$

Where

$C_{u\text{-}nat}$ = Natural uranium concentration (μCi/ml)

DCF = Inhalation dose conversion factor for U-234 contained in Federal Guidance Report 11 (EPA, 1988). Value equals 40,330 mrem/μCi.

BR = Breathing rate of 8.4 x 10^9 ml/year (Data Collection Handbook, ANL, 1993)

T = Time period of 1 year

FO = Shielding Factor for Inhalation Pathway = 0.45 as calculated using Equation 2.4 (Data Collection Handbook, ANL, 1993)

$$FO = (TF_1 x\ 1) + (TF_2 x\ 0.4) + (TF_3 x\ 0) \qquad \text{(Equation 2.4)}$$

Where

TF_1 = Fraction of time spent on site, outdoors (0.25) (Data Collection Handbook, ANL, 1993)

TF_2 = Fraction of time spent on site, indoors (0.5) (Data Collection Handbook, ANL, 1993)

TF_3 = Fraction of time spent off site (0.25) (Data Collection Handbook, ANL, 1993)

The result of this calculation shows that by using realistic assumptions, the natural uranium concentration in air needed to approach 5 percent of the most restrictive 40 CFR 190 standard is 8.2×10^{-15} µCi/ml. The highest LLD for air concentrations of natural uranium was 7.1×10^{-15} µCi/ml. This LLD is sensitive enough to evaluate the recommended siting criteria for air particulate monitoring at a location at or above 5 percent of the 40 CFR 190 standards. In addition, this dose level (1.25 mrem) is lower than the dose (5 mrem) resulting from the LLD recommendations for stack effluent samples contained in Section 5.0 of Regulatory Guide 4.14.

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

2.9.6.3 Conclusions

With the exception of natural uranium, the values determined above are similar to U.S. background concentrations reported in the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex B. The regional concentrations reported in this reference document are: 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^2s)	Std. Dev. (pCi/m^2s)	LLD (pCi/m^2s)	Average Flux @ Location (pCi/m^2s)
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 Surface Water and Groundwater Sampling

At the project site, baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980). Because of the significant number of groundwater wells, their geochemical similarities, and an abundance of historical water quality data, a representative subset of the wells was selected for sampling. The wells were selected based on type of use, aquifer, and location in relation to the ore bodies. For the baseline study for the NRC permit, 19 groundwater wells (14 existing and 5 newly drilled) were selected as making up a representative sampling group for the area (Figure 2.7-30, Table 2.7-28). The wells selected for sampling include eight domestic wells, six stock watering wells, and five monitor wells. The subset includes wells within the Fall River Formation (6), Chilson Member of the Lakota Formation (7), Inyan Kara Group (Fall River and Chilson) (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from the 3rd quarter 2007 through the 2nd quarter 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 14 wells were sampled monthly beginning in early 2008 and continuing through early 2009 (Figure 2.7-31, Table 2.7-29). Of these 14 wells, six wells are in the Dewey area, six wells are near Burdock, and two wells are north of the project area.

Comprehensive information on well locations and all water quality parameters is provided in sections of the project related specifically to groundwater (Section 2.7.3.2).

2.9.8.1 Methods

Surface water sample collection and analysis methods are discussed in Section 2.7.3.1.3. Groundwater sample collection and analysis methods are described in Section 2.7.3.2.2 and summarized below.

Surface water and groundwater samples collected as part of the baseline monitoring program were analyzed for constituents listed in Table 2.7-22. The constituents met the recommendations of Regulatory Guide 4.14 and NUREG-1569 Table 2.7.3-1. Metals were analyzed for dissolved fractions, while radionuclides were typically analyzed for the dissolved and suspended fractions. In some samples analysis was also completed for total metals and total radionuclides.

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

Exceptions to this were domestic wells that could not be accessed at the well head or were behind a pressure tank (wells 7, 8, 13, 16, 18, 42), free-flowing wells that could not be sealed due to leaks caused by corrosion and age (wells 2, 5, 4002), free-flowing wells that could not be sealed due to poor valve fittings or cracked valves (well 696), free-flowing wells where existed the possibility of rupturing a line when pressurized due to age (well 7002), and wells that contained pumps and pump tubing making it difficult to retrieve a water level tape (well 619).

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

Continuous free-flowing wells were sampled before pressure measurements were made and were not purged before sampling. For these wells (2, 5, 18, 42, 4002, 7002), it was assumed that free-flowing well water adequately represented formation water. After collecting a sample, a spot check with a water-quality probe was made and temperature, specific conductivity, turbidity, and pH were recorded. Pressure was then measured at the wells where it was possible within limits of feasibility.

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

to the well and water quality parameters were periodically recorded. If parameters had not stabilized after purging 3 volumes, wells were allowed to continue to purge until parameters had stabilized, or until the purged volume was >> 3 well volumes.

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

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

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

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

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

Additional steps taken during water quality sampling include the following:

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

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

2.9.8.2 Surface Water and Groundwater Sampling Radiological Results

Surface and groundwater quality sampling results are provided in the following appendices:

- Appendix 2.7-C Surface Water Quality Summary Tables
- Appendix 2.7-F Surface Water Analytical Results
- Appendix 2.7-G Groundwater Quality Summary Tables
- Appendix 2.7-H Groundwater Analytical Results
- Appendix 2.9-I Radionuclide Concentrations in Surface Water
- Appendix 2.9-J Radionuclide Concentrations in Groundwater

The tables in Appendices 2.9-I (surface water) and 2.9-J (groundwater) include the value, precision and MDC format, where available (see discussion below), and other information to meet the format detailed in Table 2.9.3-1 of NUREG-1569. Where the earlier reporting format

was used by the laboratory and where a result was reported as non-detect, a less than sign and the reporting limit are provided in the summary tables.

Analytical data provided by the contracting laboratory during the early part of Powertech (USA)'s baseline study were reported in a "not detected (ND) at reporting limit (RL)" format. During the course of the baseline study, the contracting laboratory, Energy Laboratories, Inc., implemented the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) process. Analytical data derived from the MARLAP process are reported in a "value, precision and minimum detectable concentration (MDC)" format. Energy Laboratories, Inc. has advised Powertech (USA) that it is not possible to reprocess earlier ND/RL data into the value/precision/MDC format (value/error/LLD format) referenced in Regulatory Guide 4.14. As a result, both reporting formats, the earlier ND/RL and the later value/precision/MDC format, appear in Powertech (USA)'s water quality radiological summary tables and laboratory analytical data packages. Following is a description of how the MDC is used in place of the LLD in the summary tables.

The lower limit of detection (LLD) is defined in MARLAP (2004) as the following: "(1) The smallest concentration of radioactive material in a sample that will yield a net count, above the measurement process (MP) blank, that will be detected with at least 95 percent probability with no greater than a 5 percent probability of falsely concluding that a blank observation represents a real signal (NRC, 1984). (2) An estimated detection limit that is related to the characteristics of the counting instrument (EPA, 1980)."

The calculation referenced in several NRC documents for LLD is generally in the form:

$$LLD = \frac{4.66 \times \sigma_b}{2.22 \times E \times M \times R \times I}$$

Where:

LLD	=	Lower limit of detection as an a priori determination
σ_b	=	Standard deviation of the instrument background count rate (counts/min)
M	=	The sample weight (g) or volume (L)
E	=	Instrument efficiency for alpha or beta
R	=	Yield for the individual radionuclide as determined by tracer or carrier
I	=	Ingrowth factor
2.22	=	Conversion for dpm to pCi

Following is an evaluation of the surface and groundwater sampling radiological results.

Surface Water

Following is a description of the surface water sampling radiological results for select stream sampling sites (BVC01, PSC01 and UNT01) and impoundment sampling sites based on questions from NRC staff. Complete surface water quality and radionuclide summary tables are provided in Appendices 2.7-C and 2.9-I, respectively. Laboratory analytical reports are provided in Appendix 2.7-F. For a summary of the sampling conducted at the stream and impoundment sampling sites, refer to Section 2.7.3.1.

As part of the baseline monitoring program, surface water station BVC01 was visited monthly from July 2007 to June 2008. Water samples were collected from the site each month except February 2008, when the site was ice covered. The following summarizes the samples and results.

- Ra-226, dissolved: Nine samples were analyzed. The results show the concentrations were less than the MDC in seven of the samples. The highest concentration was 2 ± 0.4 pCi/L.
- Ra-226, suspended: Nine samples were analyzed for Ra-226, suspended. Only two samples measured concentrations above the MDC. The highest concentration was 3.1 ± 1.6 pCi/L.
- Th-230, dissolved: Nine samples were analyzed only one measured a concentration above the MDC: 0.3 ± 0.3 pCi/L.
- Th-230, suspended: Five of the nine samples analyzed were equal to or less than the MDC. The highest concentration of 3.4 ± 1.1 pCi/L was measured in May 2008.
- Uranium, dissolved: Nine samples were analyzed. The average concentration for the samples was 0.0124 mg/L, with the highest concentration of 0.0269 mg/L measured in March 2008.
- Uranium, total: All 11 samples were analyzed for total uranium. The average concentration for the samples was 0.0121 mg/L.

Passive samplers were installed at sites PSC01 and UNT01 as part of the baseline monitoring program described in Section 2.7.3.1.1. The samplers were set up to automatically collect a sample in the event of an ephemeral flow event. During baseline monitoring two samples were collected from site PSC01 and one sample was collected from site UNT01. Of the three samples, only one of the PSC01 samples (July 2008) was analyzed for Pb-210 and Po-210. The laboratory results for dissolved and suspended Pb-210 were 2.2 ± 4.5 pCi/L and 0.9 ± 7.0 pCi/L. The results

for dissolved and suspended Po-210 were 0.7 ± 0.70 pCi/L and 0.3 ± 0.33 pCi/L. All results were below the laboratory minimum detectable concentration (MDC).

An evaluation of water quality for all of the stream monitoring sites was completed for Pb-210 and Po-210 concentrations. The following summarizes the results:

- Pb-210, dissolved: 17 of the 24 samples were below the laboratory MDC. The highest concentration, 26 ± 2.6 pCi/L, was measured at site BVC04 in December 2007.
- Pb-210, suspended: 20 of the 24 samples were below the laboratory MDC. Site CHR05 measured the highest concentration of 22 ± 3.6 pCi/L in January 2008.
- Po-210, dissolved: 14 of the 24 samples were below the laboratory MDC. The highest concentration, 3 ± 1.7 pCi/L, was measured at site BVC04 in October 2007.
- Po-210, suspended: 13 of the 24 samples were below the laboratory MDC. Site CHR01 measured the highest concentration of 4.1 ± 3.2 pCi/L in May 2008.

As part of the baseline monitoring program 11 impoundments (Sub01 through Sub11) were visited on a quarterly basis between July 2007 and June 2008. When water was available, water samples were collected from each impoundment and analyzed for the constituents listed in Table 2.7-22. The following summarizes the sampling conducted and radionuclide analytical results for the nine impoundments (SUB01, SUB03, SUB04, SUB05, SUB06, SUB08, SUB09, SUB10, and SUB11).

Sub01

Sub01 was visited in September 2007, November 2007, March 2008, and June 2008. In September 2007 and November 2007 the impoundment was dry and no samples were collected, thus explaining the two missing quarterly samples. Quarterly samples collected in March and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Since Po-210 and Pb-210 were on the semiannual analysis schedule rather than quarterly per recommendations in Regulatory Guide 4.14, the constituents were not analyzed in the March 2008 water sample. Both Po-210 and Pb-210 were analyzed in the water sample collected in June 2008. Since Sub01 is not located downstream from proposed activities or within the project area (as described in Section 5.7.8.1), no operational monitoring is proposed at this impoundment.

Sub03

Sub03 was visited in September 2007, November 2007, February 2008, March 2008, and June 2008. The impoundment was dry in September 2007, February 2008, and March 2008 and no

samples were collected, thus explaining the two missing quarterly samples. Quarterly samples collected in November 2007 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Sub03 will be included in the operational monitoring program.

Sub04

Sub04 was visited in September 2007, November 2007, February 2008, March 2008, and June 2008. The impoundment was dry in September 2007, February 2008, and March 2008 and no samples were collected at those times. Quarterly samples collected in November 2007 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. During operations Sub04 will be included in the operational monitoring program.

Sub05

Sub05 is a detention pond below the Darrow surface mines and was visited quarterly. During each monitoring site visit the impoundment was dry and no samples were collected. As described in Section 5.7.8.1, Sub05 will be included in the operational monitoring program.

Sub06

The surface water quality summary tables have been corrected to show that Ra-226 (dissolved) was analyzed during all four quarters.

Sub08

The revised surface water quality and radionuclide summary tables in Appendix 2.7-C and 2.9-I show that Ra-226 (dissolved) was analyzed during all four quarters.

Sub09

Sub09 was visited in September 2007, November 2007, March 2008, and June 2008. The impoundment was dry in September 2007 and November 2007 and no samples were collected at those times. Quarterly samples collected in March 2008 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Since Po-210 and Pb-210 were on the semiannual analysis schedule rather than quarterly per recommendations in Regulatory Guide 4.14, the constituents were not analyzed in the March 2008 water sample. Both Po-210 and Pb-210 were analyzed in the water sample collected in June 2008. Sub09 will be included in the operational monitoring program.

Sub10

Sub10 was visited in September 2007, November 2007, March 2008, and June 2008. The impoundment was dry in September 2007 and November 2007 and no samples were collected at those times. Quarterly samples collected in March 2008 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Since Po-210 and Pb-210 were on the semiannual analysis schedule rather than quarterly per recommendations in Regulatory Guide 4.14, the constituents were not analyzed in the March 2008 water sample. Both Po-210 and Pb-210 were analyzed in the water sample collected in June 2008. Sub10 will be monitored as part of the operational surface water monitoring program.

Sub11

The surface water quality and radionuclide summary tables in Appendix 2.7-C and 2.9-I show that Ra-226 (dissolved) was analyzed during all four quarters.

Groundwater

Results to date for radiological groundwater parameters are shown in Appendix 2.9-J.

Relationships between Dissolved, Suspended and Total Fractions

Surface water and groundwater samples collected as part of the baseline monitoring program were analyzed for constituents listed in Table 2.7-21. Metals were analyzed for dissolved fractions, while radionuclides were typically analyzed for the dissolved and suspended fractions. In some samples analysis was also completed for the total metals and total radionuclides.

Relationships between dissolved and suspended radionuclide concentrations were evaluated for both the groundwater and surface water. Based on a comparison of all radionuclide concentrations in groundwater provided in Appendix 2.9-J, the dissolved and suspended radionuclide fractions in groundwater were generally similarly small. However, some differences are apparent. For example, approximately half (51%) of the Pb-210 analyses were higher for the dissolved fraction versus suspended (36% - the remaining 13% were equal). Higher dissolved fractions were most apparent in Ra-226 and uranium. During the baseline monitoring 244 groundwater samples were analyzed for both dissolved and suspended Ra-226. The results show that the majority (91%) of the samples measured higher dissolved than suspended Ra-226. The maximum dissolved Ra-226 measured was 1,440 pCi/L, while the maximum suspended Ra-226 concentration was 15.3 pCi/L. Similarly, dissolved uranium was measured at higher concentrations than the suspended fraction (nearly 70%).

Relationships for the surface water radionuclide concentrations (Appendix 2.9-I) indicated that suspended fractions are slightly higher for all constituents, with the exception of uranium. The results show that the majority (83.5%) of the samples measured higher dissolved uranium. Overall, the concentrations of radionuclides in surface water are generally near or below the applicable detection limits.

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2.9.8.3 Conclusions

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

2.9.9 Vegetation Sampling

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

Grass is the primary animal forage vegetation within the project area. Therefore, consistent with Regulatory Guide 4.14, grasses were the only type of forage vegetation sampled during background radiological characterization.

Vegetation samples were collected from representative grazing areas in sectors near the air monitoring stations (AMS). These stations were placed in areas predicted to have the highest airborne concentrations due to ISR operations. This is consistent with Table 1 in Regulatory Guide 4.14, which indicates that radiological sampling will be conducted in grazing areas having the highest predicted air particulate concentrations during milling operations.

2.9.9.1 Methods

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

2.9.9.2 Vegetation Sampling Results

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

- Radium-226 concentrations ranged from 0.02 to 0.09 pCi/g, averaging 0.05 pCi/g.
- Natural uranium concentrations ranged from 0.01 to 0.04 pCi/g, averaging 0.02 pCi/g.
- 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.

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

Powertech (USA)'s original assessment of land use for food sources resulted only in the identification of cattle grazed within 3.3 km of the project area. Powertech (USA) has since conducted additional investigations and determined that in addition to cattle there are "free range" pigs and vegetable gardens within 3.3 km of the project area. While chickens are also present with 3.3 km of the project area, they are fed grains not originating from the project area and are not considered grazing animals. Therefore, Powertech (USA) does not propose to sample chickens. Figure 2.9-15 has been prepared to show the updated assessment of land use for food sources within 3.3 km of the project area.

Note that Figure 2.9-15 does not depict game animals, since game animals observed in the vicinity of the project area have extensive ranges that are not confined to a particular area within the scale of Figure 2.9-15. Powertech (USA) interpreted RG 4.14 as requiring animal tissue sample analysis for livestock only, particularly in light of recently approved NRC license applications (e.g., Moore Ranch ISR Project, SUA-1596) that have not provided game animal tissue sample analyses. As additional justification for not sampling wildlife tissue, the migratory nature and relatively large home range of game animals observed in the area in relation to the size of the project area make it difficult to relate radionuclide concentrations to a particular site.

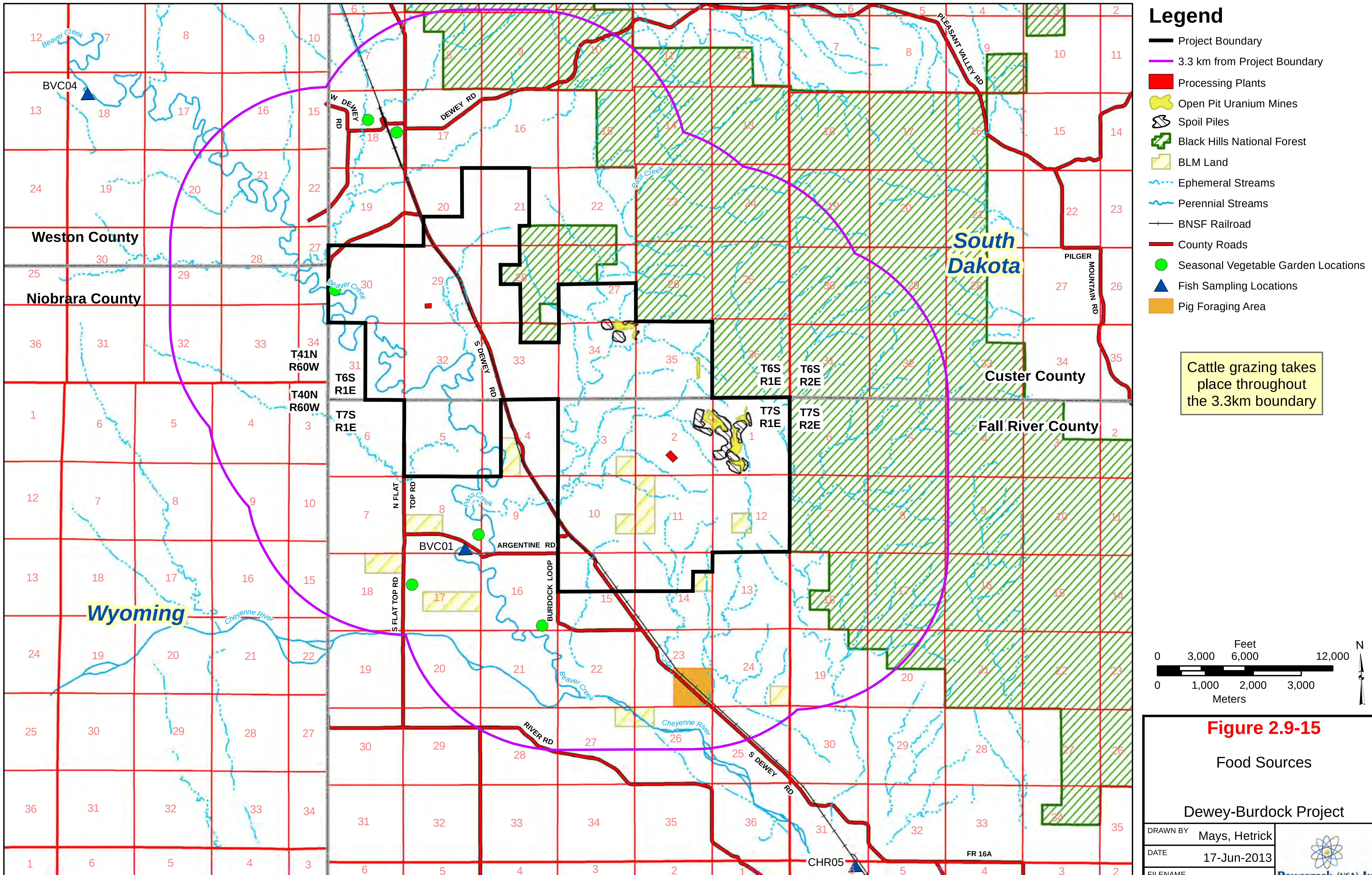

Figure 2.9-15

Food Sources

Section 1.1.3 of Regulatory Guide 4.14 states:

"At least three samples should be collected at time of harvest or slaughter or removal of animals from grazing for each type of crop (including vegetable gardens) or livestock raised within three kilometers of the mill site."

Powertech (USA)'s original interpretation of Regulatory Guide 4.14 was to collect three samples from each type of animal. Therefore, three samples were originally collected from one locally grazed cow. Pursuant to NRC staff interpretation that one sample each should be collected from three different specimens of each type of livestock, the following actions have been performed or will be performed prior to ISR operations:

- Samples from one additional cow have been analyzed for the recommended analytes in Regulatory Guide 4.14.
- Powertech (USA) commits to sampling one additional cow prior to ISR operations, bringing the total to three.
- Samples from one free ranging, locally grazed pig have been analyzed for the recommended analytes in Regulatory Guide 4.14.
- Powertech (USA) commits to sampling two additional pigs prior to ISR operations, bringing the total to three.

The results of all food samples available to date are shown in Table 2.9-19.

Table 2.9-19 and Appendix 2.9-A, Table 10-1 are in a format consistent with Regulatory Guide 4.14, Section 7.5 with the exception of data reported for natural uranium (U-nat), which cannot be reported in this format due to the quantification method used. U-nat concentrations in tissue were evaluated using EPA Method SW6020, which uses ICP-MS and is not a radiochemical method. The data were reported in units of mg/kg and subsequently converted to units of activity by using the specific activity for natural uranium of 6.77 x 10^{-4} μCi/mg. Error estimates are not evaluated on an individual sample basis using EPA Method SW6020, which is why no error estimates are presented in Table 2.9-19 and Appendix 2.9-A, Table 10-1 for individual samples. EPA Method SW6020 discusses controlling analytical error by evaluating laboratory control samples such as Matrix Spikes (MS) and Matrix Spike Duplicates (MSD) and establishing control limits for accuracy and precision. The data reported in the above mentioned tables met Energy Laboratories Inc. internal quality control measures.

Table 2.9-19: Baseline Radionuclide Concentrations in Local Food

Sample ID	Radionuclide	Parameter	Result
DBAT-01 (Meat sample from locally grazed cow, June 2008)	U-nat (µCi/kg)	Concentration	< 7.0E-06
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	3.0E-06
		Error ± 2σ	2.0E-06
		LLD	3.0E-06
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	2.0E-05
		LLD	8.0E-06
	Pb-210 (µCi/kg)	Concentration	-7.0E-06
		Error ± 2σ	4.0E-05
		LLD	7.0E-06
	Po-210 (µCi/kg)	Concentration	8.0E-06
		Error ± 2σ	1.0E-04
		LLD	8.0E-06
DBAT-02 (Meat sample from locally grazed cow, June 2008)	U-nat (µCi/kg)	Concentration	< 7.0E-06
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	6.0E-05
		Error ± 2σ	3.0E-05
		LLD	4.0E-05
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.4E-03
		LLD	1.0E-04
	Pb-210 (µCi/kg)	Concentration	2.0E-04
		Error ± 2σ	7.0E-04
		LLD	1.2E-03
	Po-210 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.2E-03
		LLD	1.0E-04
DBAT-03 (Liver sample from locally grazed cow, June 2008)	U-nat (µCi/kg)	Concentration	< 7.0E-06
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	3.0E-06
		Error ± 2σ	1.0E-06
		LLD	2.0E-06
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.0E-04
		LLD	6.0E-06
	Pb-210 (µCi/kg)	Concentration	-7.0E-06
		Error ± 2σ	4.0E-05
		LLD	6.0E-05
	Po-210 (µCi/kg)	Concentration	2.0E-05
		Error ± 2σ	2.0E-04
		LLD	6.0E-06

Table 2.9-19: Baseline Radionuclide Concentrations in Local Food (Concl.)

Sample ID	Radionuclide	Parameter	Result
Pork (April 2011)	U-nat (µCi/kg)	Concentration	8.1E-06
		Error ± 2σ	-
		LLD	2.0E-07
	Ra-226 (µCi/kg)	Concentration	7.9E-07
		Error ± 2σ	1.6E-07
		LLD	1.4E-07
	Th-230 (µCi/kg)	Concentration	-1.7E-05
		Error ± 2σ	4.4E-06
		LLD	7.2E-06
	Pb-210 (µCi/kg)	Concentration	-3.4E-07
		Error ± 2σ	1.0E-06
		LLD	1.7E-06
Beef (April 2011)	U-nat (µCi/kg)	Concentration	2.3E-06
		Error ± 2σ	-
		LLD	2.0E-07
	Ra-226 (µCi/kg)	Concentration	6.0E-07
		Error ± 2σ	1.5E-07
		LLD	1.4E-07
	Th-230 (µCi/kg)	Concentration	1.8E-06
		Error ± 2σ	2.6E-06
		LLD	4.9E-06
	Pb-210 (µCi/kg)	Concentration	1.1E-06
		Error ± 2σ	6.3E-07
		LLD	4.4E-07

Note: U-nat analyzed using ICP-MS; therefore, error estimate is not available.

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

The current use of the data in Table 2.9-19 and Appendix 2.9-A, Table 10-1 is to provide a pre-operational baseline concentration of radionuclides in animal tissue. NUREG/CR-4007 (NRC, 1984) states that any measurement process must be capable of detecting the relevant radionuclides at levels well below those of concern to the public health and safety. Powertech (USA) is not aware of regulatory limits for radionuclides in food items to evaluate the appropriate sensitivity of the analytical methods used. For justification purposes herein, it was assumed that 10 percent of the total effective dose equivalent public dose limit of 100 mrem per year in 10 CFR 20 would be an appropriate comparison for food items.

Equation 2.5 was used to determine the concentration in food products, in this case beef or pork, that would result in a dose equivalent of 10 percent of the public dose limit standard in 10 CFR 20. Table 2.9-20 shows the results of the radionuclide concentrations in beef that meet this criteria and the dose conversion factors used.

$$C_i = \frac{10\ mrem/yr}{IxDCF_i} \qquad \text{(Equation 2.5)}$$

Where:

C_i = Concentration of radionuclide (i) in beef that would result in dose equivalent of 1.25 mrem/y (μCi/kg)

10 mrem = 10% of 10 CFR 20 public dose limit of 100 mrem/year (CEDE)

DCFi = Dose Conversion Factor for ingestion of radionuclide (i) (mrem/μCi) [Federal Guidance Report 11 (EPA, 1988)]

I = Beef intake rate for adult (27 kg/y) [Data Collection Handbook (ANL, 1993)]

Table 2.9-20: Effective Dose Conversion Factors Used in and Results for Equation 2.5

Radionuclide	DCF (mrem/µCi)	Concentration (µCi/kg)
Natural uranium*	283	1.3×10^{-3}
Thorium-230	548	6.8×10^{-4}
Radium-226	1,325	2.8×10^{-4}
Lead-210	5,365	6.9×10^{-5}
Polonium-210	1,902	1.9×10^{-4}

* DCF for Uranium-234 was used since it is the most restrictive of the three uranium isotopes in natural uranium

Based on the justification above, LLDs for beef or pork tissue should be below the concentrations presented in Table 2.9-20. A comparison of the baseline monitoring program results in Table 2.9-19 indicates that all but one LLD for beef tissue (Pb-210 in DBAT-02) was well below the concentration values in Table 2.9-20. Powertech (USA) has submitted an additional beef sample for laboratory analysis and commits to sampling a third locally grazed cow prior to ISR operations. The goal will be to meet the LLDs contained in Regulatory Guide 4.14, but in no case will reported LLDs be greater than values contained in Table 2.9-20.

The meat LLDs in Table 2.9-19 and Appendix 2.9-A, Table 10-1 are substantially different from each other because of differences in matrix interference, sample size, and low radionuclide concentrations within the sample matrix. The potential for this result is acknowledged in NUREG/CR-4007, which states that "the critical (decision) level and detection limit (LLD) really do vary with the nature of the sample" and that "proper assessment of these quantities demands relevant information on each sample, unless the variations among samples are quite trivial" (NRC, 1984).

Powertech (USA) original assessment of land use for food sources did not identify any vegetable gardens within 3.3 km of the project area. Powertech (USA) has since determined that vegetable gardens are present in the town of Dewey and at one location within the project area as shown on Figure 2.9-15. Due to the large sample size (> 10 lbs) typically required to satisfy RG 4.14 suggested LLDs for vegetation and the relatively small size of the vegetable gardens, Powertech (USA) is implementing the following alternate approach to sampling vegetables from local gardens.

Prior to operations, Powertech (USA) will sample vegetable garden soil rather than the vegetables themselves and then apply plant-to-soil concentration factors to estimate the radionuclide concentrations in vegetables. Methods and parameters contained in NUREG-5512 (NRC, 1992a) will be used to estimate radionuclide concentrations in root and leafy vegetables

based on soil radionuclide concentrations. Equation 2.6, obtained from Section 5 (Equation 5.5) of NUREG-5512, will be used to calculate vegetable concentration factors as follows:

$$C_{svhj} = 1000(ML_v + B_{JV})W_v \{AC_{sj}, t_{gv}\}/C_{sj} \qquad \text{(Equation 2.6)}$$

Where:

C_{svhj} = concentration factor for radionuclide j in plant v at harvest from an initial unit concentration of parent radionuclide i in soil (pCi/kg wet-weight plant per pCi/g dry-weight soil)

B_{JV} = concentration factor for uptake of radionuclide j from the soil in plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)

ML_v = plant soil mass-loading factor for resuspension of soil to plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)

W_v = dry to wet-weight conversion factor (unitless)

$\{AC_{sj}, t_{gv}\}$ = decay operator notation used to develop the concentration of radionuclide j in soil at the end of the crop growing period t_{gv} (pCi/g dry-weight)

C_{sj} = concentration of radionuclide j in soil during the growing period (pCi/g dry-weight)

$C_{sj}(0)$ = initial concentration of radionuclide j in soil during the growing period (pCi/g dry-weight)

t_{gv} = growing period for food crop (d)

1000 = unit conversion factor (g/kg)

The radionuclides recommended for analysis in vegetation in RG 4.14 are natural uranium, thorium-230, radium-226, lead-210, and polonium-210. These radionuclides, with the exception of polonium-210, have long half-lives when compared to the growing season; therefore, the decay correction during the growing season can be ignored for these parameters. For polonium-210, the initial soil concentration and soil concentration during the growing season will be assumed identical. This assumption will allow simplification of Equation 2.6 to Equation 2.7.

$$C_{svhj} = 1000(ML_v + B_{JV})W_v \qquad \text{(Equation 2.7)}$$

Table 2.9-21 presents the parameters that will be used to estimate wet-weight vegetable concentrations from dry-weight soil concentrations.

Table 2.9-21: Parameters Used to Estimate Wet-Weight Vegetable Concentrations from Dry-Weight Soil Concentrations

Parameter	Parameter Description	Plant Type	Radionuclide	Value	Unit
MLv	Mass loading factor	Root Vegetables	Parameter is not radionuclide specific.	0.1	pCi/kg dry-weight plant per pCi/g dry-weight soil
		Leafy Vegetables			
		Fruits			
BJV	Concentration factor for root uptake	Root vegetables	Natural uranium	0.014	pCi/kg dry-weight plant per pCi/g dry-weight soil
			Thorium-230	0.00012	
			Radium-226	0.0032	
			Lead-210	0.0032	
			Polonium-210	0.009	
		Leafy Vegetables	Natural uranium	0.017	
			Thorium-230	0.0025	
			Radium-226	0.075	
			Lead-210	0.0058	
			Polonium-210	0.0025	
		Fruits	Natural uranium	0.004	
			Thorium-230	0.000085	
			Radium-226	0.0061	
			Lead-210	0.009	
			Polonium-210	0.0004	
Wv	Dry weight to wet weight conversion factor	Root Vegetables	Not radionuclide specific	0.2	Unitless
		Leafy Vegetables		0.25	
		Fruits		0.18	

2.9.11 References

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3.0 Description of Proposed Facility

3.1 In Situ Leach Process and Equipment

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

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

At the surface, the pregnant lixiviant flows through IX columns, where the uranium is transferred to resin. The resin will be trucked or piped to a CPP for further refinement into yellowcake - the final product for the first stage of the uranium fuel cycle.

The barren lixiviant is re-fortified with oxygen and carbon dioxide and re-circulated through the orebody to leach uranium.

Powertech (USA) proposes to use a lixiviant consisting of varying concentrations of oxygen (O_2) and carbon dioxide (CO_2) added to the native groundwater to promote the dissolution of uranium as a uranyl carbonate anionic complex. The expected or typical lixiviant concentrations and compositions are shown in Table 3.1-1. This lixiviant formulation will minimize ground water quality potential impacts during uranium recovery and enable restoration goals to be achieved in a timely manner (NUREG-1569, 2003).

Figures 3.1-1 and 3.1-2 depict the proposed facilities in the land application and deep disposal well liquid waste disposal options, respectively. Sections 3.1.6 and 4.2.2 describe the liquid waste disposal options. Figure 3.1-3 presents a map view of the project ore bodies proposed for uranium recovery and shows all lower Fall River ore bodies in “blue,” all ore bodies within the upper Chilson Member of the Lakota Formation in “green” and middle/lower Chilson ore bodies in “red.” No potential well fields are located within 1,600 feet of the project boundary in order to establish an operational buffer between the well fields and the project boundary. In addition, no well fields are proposed for unsaturated Fall River ore bodies in the eastern portion of the project area. Figures 3.1-1, 3.1-2, and 3.1-3 show the location of all operations/infrastructure within the license boundary. All well fields and infrastructure associated with the Dewey-Burdock Project will be located within the license boundary. This includes all ISR production and injection wells, monitor wells, pipelines, and facilities.

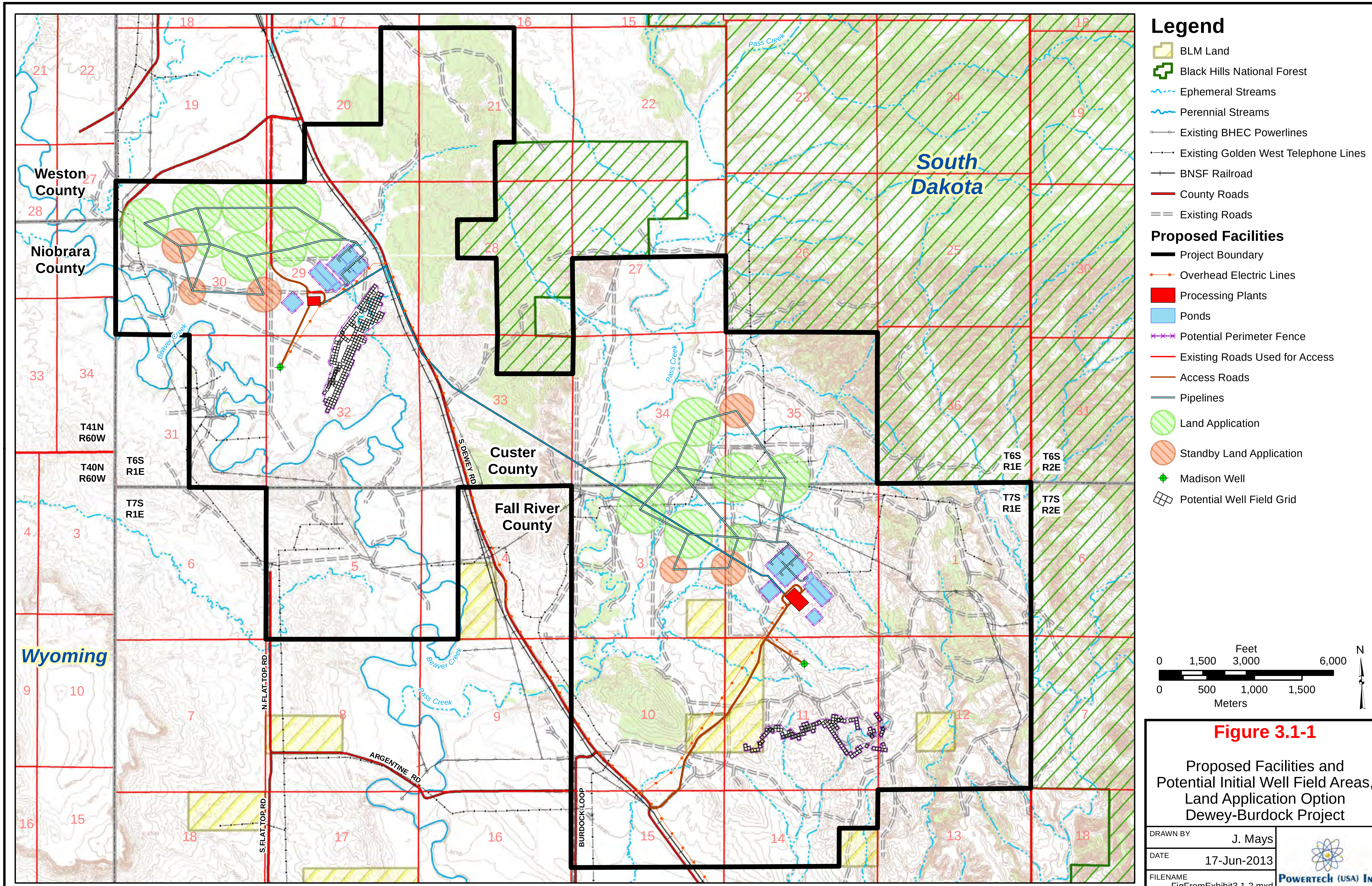

Figure 3.1-1

Proposed Facilities and Potential Initial Well Field Areas, Land Application Option Dewey-Burdock Project

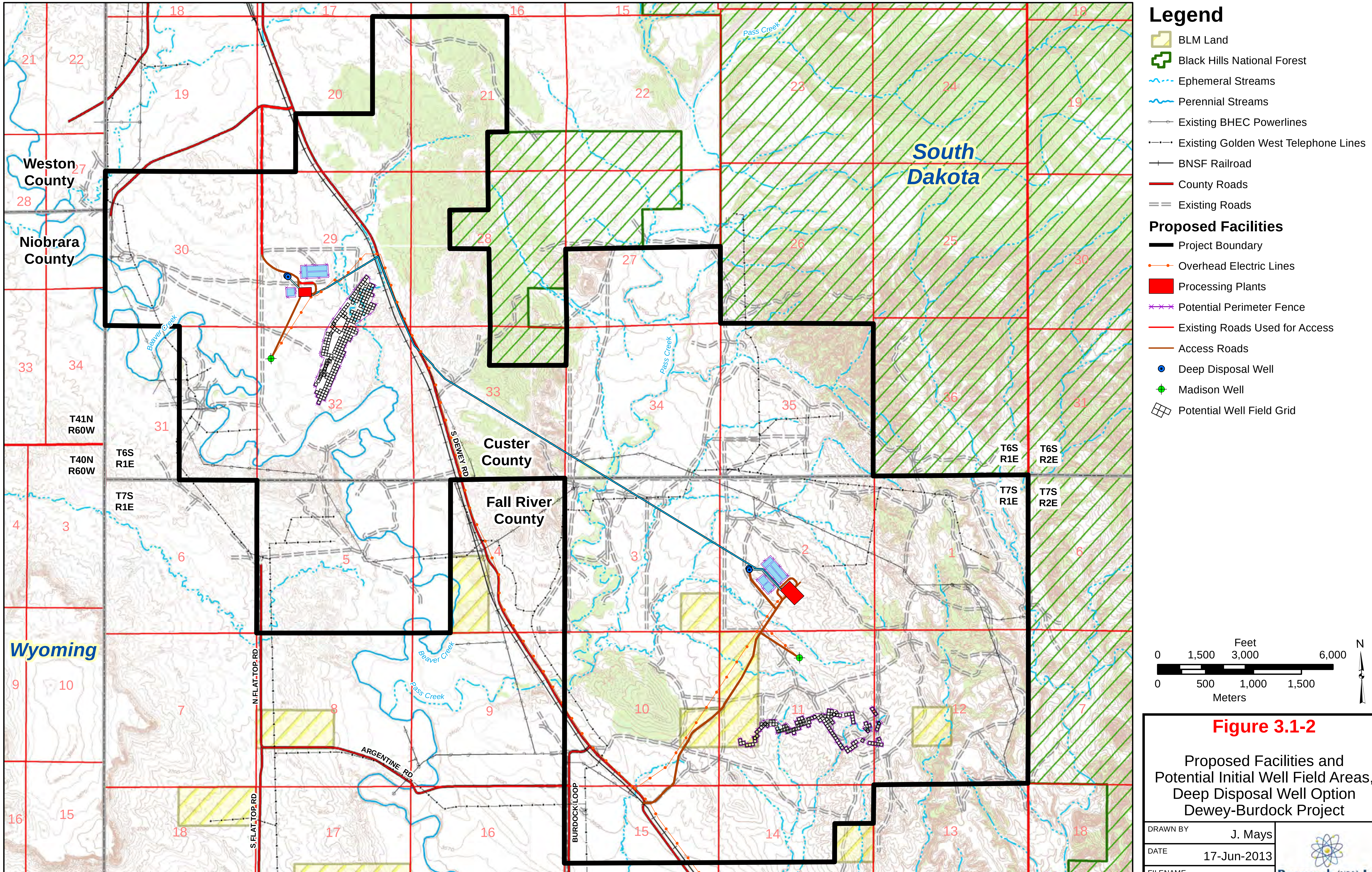

Figure 3.1-2

Proposed Facilities and Potential Initial Well Field Areas, Deep Disposal Well Option Dewey-Burdock Project

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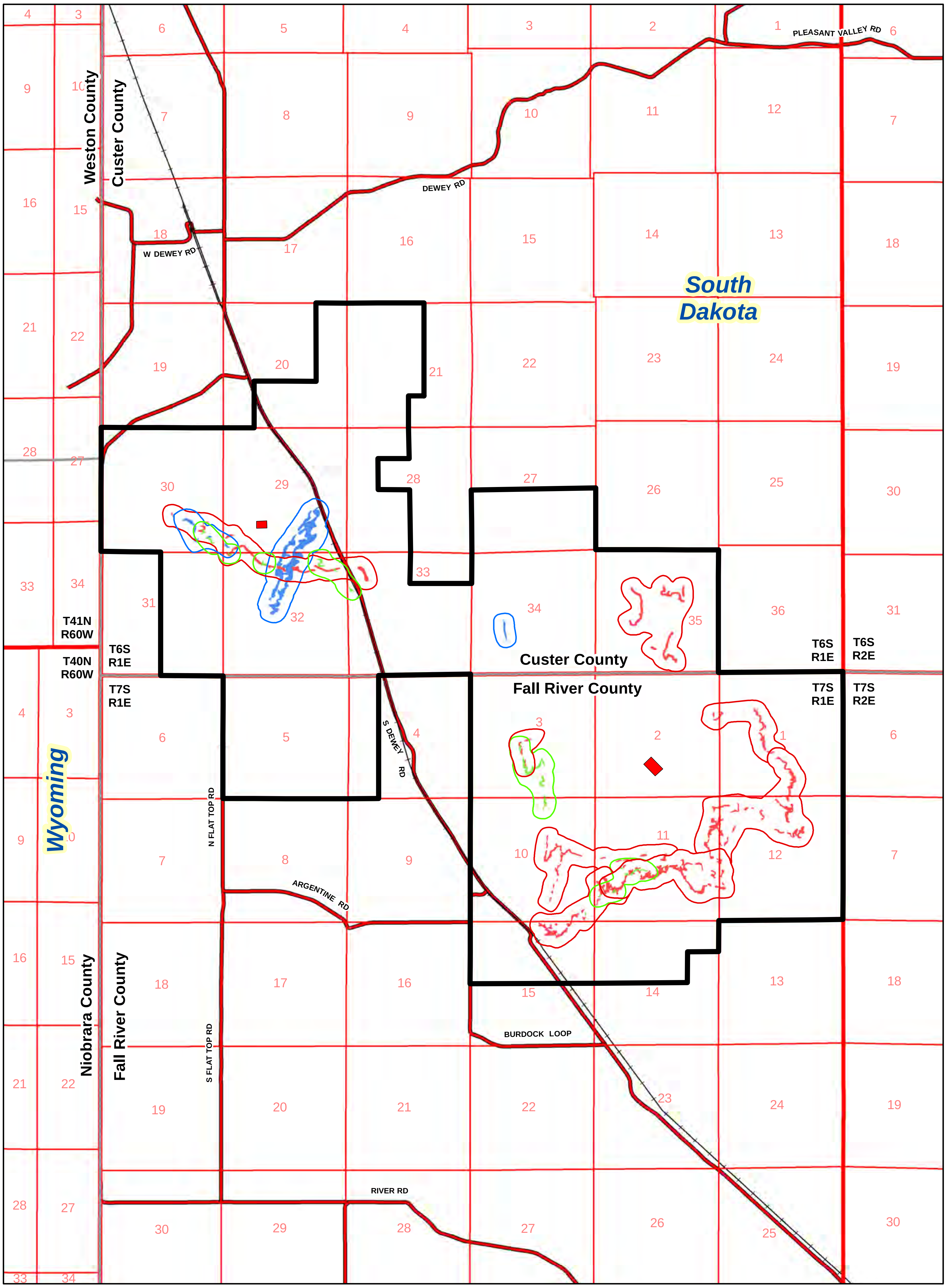
Powertech (USA) Inc.



Legend

- Project Boundary
- Processing Plants
- BNSF Railroad
- County Roads

Potential Well Field Areas

- Upper Chilson
- Middle/Lower Chilson
- Lower Fall River

Ore Bodies

- Upper Chilson
- Middle/Lower Chilson
- Lower Fall River

Figure 3.1-3

Potential Well Field Areas

Dewey-Burdock Project

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POWERTECH (USA) INC.

Table 3.1-1: Typical Lixiviant Concentrations and Compositions

Constituent	Units	Concentration Range	
		Minimum	Maximum
Calcium	mg/L	≤20	500
Sodium	mg/L	≤400	6000
Magnesium	mg/L	≤3	100
Potassium	mg/L	≤15	300
Chloride	mg/L	≤200	5000
Carbonate	mg/L	≤0.5	5000
Bicarbonate	mg/L	≤400	5000
Sulfate	mg/L	≤400	5000
Uranium	mg/L	≤0.01	500
Vanadium	mg/L	≤0.01	100
pH	Std units	≤6.5	10.5
Total Dissolved Solids, TDS	mg/L	≤1650	12000

Notes:

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

For purposes of the proposed action, it is anticipated that lixiviant concentrations will be within the parameters outlined in Table 3.1-1. The ISL process involves an oxidation step that converts uranium in the solid state to a form that is easily dissolved by the leaching fluid. The reactions representing these steps are as follows:

Oxidation: UO_2 (solid) + ½O_2 (in solution) $\rightarrow$ UO_3 (at solid surface)

Dissolution: $UO_3 + 2\ HCO_3^{-1} \rightarrow UO_2(CO_3)_2^{-2} + H_2O$

$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \rightarrow UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2\,(CO_3)_2^{-2}$ [i.e., UDC] and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$ [i.e., UTC]. The relative abundance of each is a function of pH and total carbonate strength.

The uranium-rich lixiviant is then extracted via production wells and pumped to an ion-exchange facility near the well field. At an IX facility, the uranium is removed from the pregnant lixiviant by IX onto resins.

Logistically, if the IX process occurs at a SF, the uranium-rich resin is physically removed from the IX columns at the SF and transported via tanker truck to the CPP where uranium is eluted

from the resin. Regenerated resin is then returned to the IX columns within the SF. If IX occurs at the CPP, trucking is not necessary.

The following paragraphs describe the upfront uranium processing facilities, including: well field layout; design and construction of injection, production, and monitoring wells; layout of header houses and associated infrastructure; leak detection and cleanup procedures; water balance and general well field operations; evaporation ponds and land application areas; waste disposal well sites; surface water management; quality control; 11e.(2) waste disposal agreements, and ISL references.

3.1.1 Orebody

For a description of the orebody and mineralized zones see the geology Section 2.6. The aquifer characterization is summarized in Section 2.7.

3.1.1.1 Approach to Well Field Development

An ISL well field consists of a series of injection and production wells that are completed across the target mineralization zone. Prior to design of the wells, the ore bodies will be delineated with exploration holes drilled on 100-feet centers. As discussed earlier, these holes will be geologically and geophysically logged Using this information, each new injection and production well will be assigned lateral coordinates, a ground surface elevation, depth to base of casing, i.e., top of completion interval, and length of completion interval, before it is drilled.

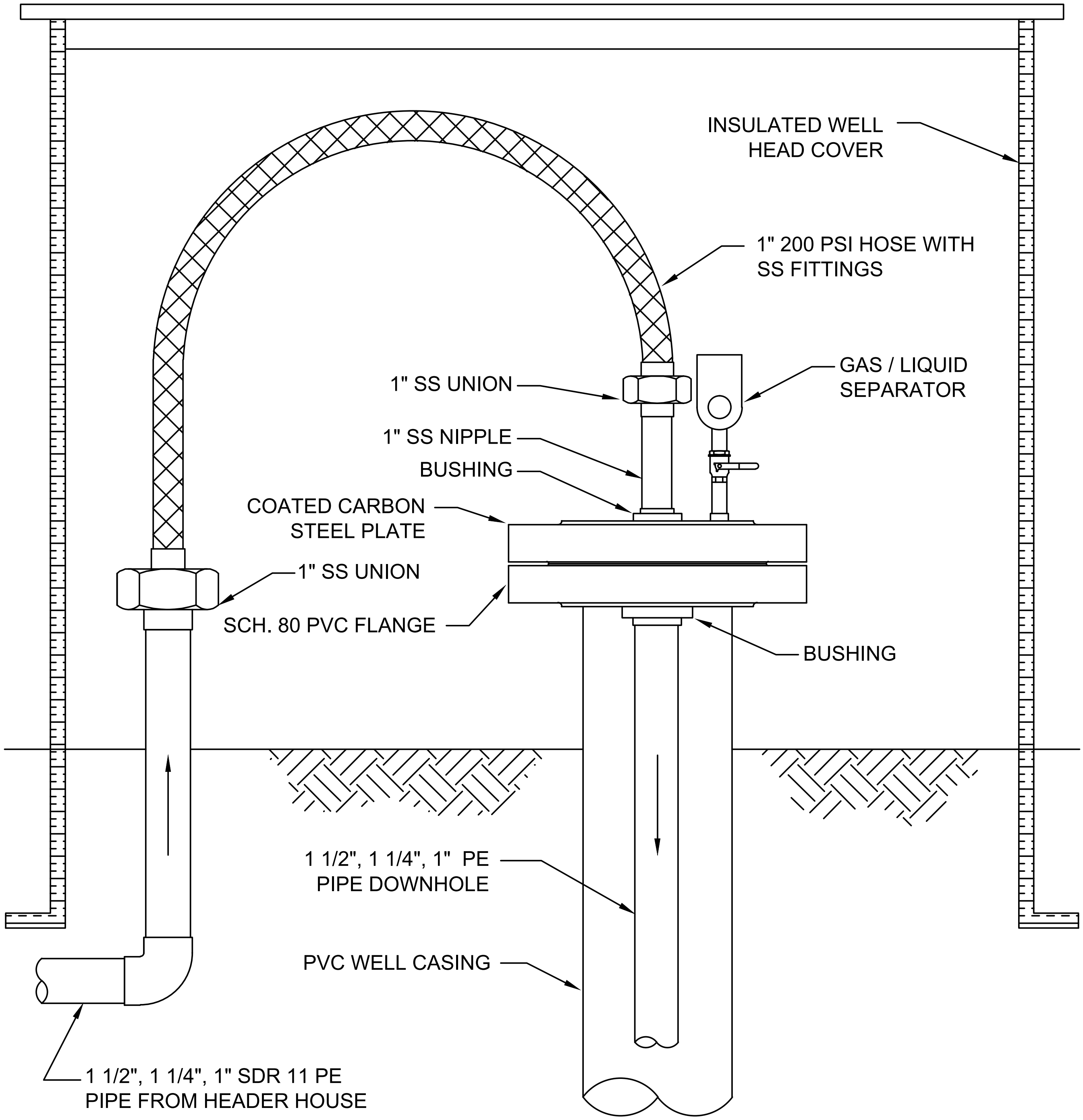
For all injection and production wells, the base of casing will be established at or below the confining unit overlying the mineralized zone. The screened interval will be completed only across the targeted ore zone.

A typical (100 x 100 ft grid) well field layout is illustrated on Plates 3.1-2 through 3.1-5. This typical layout is based on the lateral distribution and grade of one of the uranium deposits within the PAA.

The well field patterns may differ from well field to well field, but a typical pattern will consist of five wells, with one well in the center and four wells surrounding it oriented in four corners of a square between 50 and 150 feet. Typically, a production well is located in the center of the pattern, and the four corner wells are injection wells. Such a pattern will be modified as needed to fit the characteristics of each orebody. A typical well pattern for an orebody is illustrated in Plates 3.1-2 through 3.1-5.

The pattern dimensions will vary depending on the geometry of the orebody. All wells will be completed so they can be used as either injection or production wells, so that well field flow patterns can be changed as needed to improve uranium production and restore groundwater quality in the most efficient manner. Other well field designs that may be considered include alternating single lines of production and injection wells.

Production and injection wells will be connected to a common header house, as shown on Plate 3.1-6. Well head connection details for injection and production wells are illustrated on Figures 3.1-4 and 3.1-5, respectively.



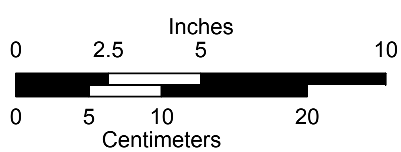


Figure 3.1-4

Typical Injection Wellhead

Dewey-Burdock Project

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DATE	17-Jun-2013
FILENAME	Wells-InjWellhead.dwg

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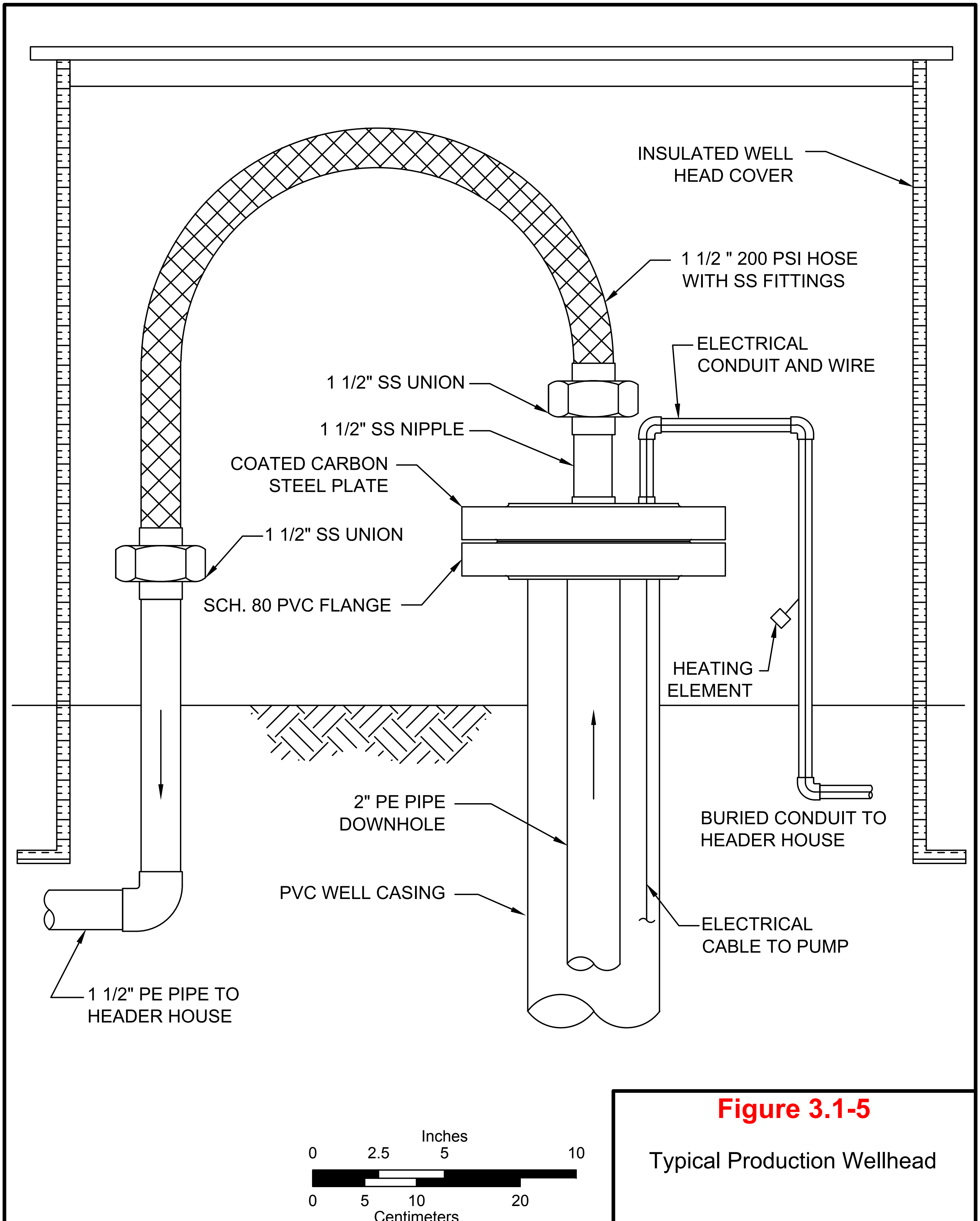

Figure 3.1-5

Typical Production Wellhead

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Wells-ProdWellhead.dwg

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Typically, one header house will service up to 20 production wells and 80 injection wells. Piping between the wells and header house will consist of high density polyethylene (HDPE) pipe with heat-welded joints, buried below the frost line, approximately 5 feet below grade. The piping will typically be designed for operating pressure of 150-300 psig, but actual pressures will typically be less than 100 psig. The piping will terminate at the header house where it will be connected to manifolds equipped with control valves, flow meters, check valves, pressure sensors, oxygen and carbon dioxide feed systems (injection only), and programmable logic controllers. Electrical power to the header houses will be delivered via overhead power lines and via buried cable. Electrical power to the header houses will be delivered via overhead power lines and via buried cable (see Figures 3.1-1 and 3.1-2). Electrical power to individual wells will be delivered via buried cable from the header house.

As a well field expands, additional header houses will be constructed. They will be connected to one another via buried header piping that is sized to accommodate the necessary injection and production flow rates and pressures. In turn, header pipes from entire well fields will be connected to either a SF or CPP, as discussed earlier. A piping detail that shows the connection between the main header piping and laterals to header houses is shown in Plate 3.1-6.

Monitoring wells will be positioned around the perimeter of each well field ring, as illustrated on Plates 3.1-2 through 3.1-5. Internal to the well field additional monitoring wells will be installed. Perimeter wells will be screened across the entire production zone to monitor for potential lateral excursion within the zone outside the well field, and to demonstrate compliance with groundwater quality standards within this zone. Internal monitoring wells will be screened across the overlying and underlying aquifers, respectively, where the greatest potential for vertical excursion may occur.

The “greatest potential for excursion” is defined as those locations where an excursion has the greatest potential to occur based on the hydrogeologic data obtained and analyzed during development of the detailed well field package. This could include, for example, areas of higher permeability, pronounced anisotropy (varying hydrologic parameters measured in varying directions), and similar features that could create a preferential flow path for ISR fluids. At a minimum, monitor wells will be installed in the overlying aquifer at a density of one well per 4 acres of area under well pattern and in the underlying aquifer at a density of one well per

4 acres per the guidance provided in NUREG-1569. In assessing the potential for a vertical excursion to occur, the following criteria will be applied for installing overlying and underlying monitor wells within the pattern:

- Areas which may be associated with leakage around the injection well casing.
- Areas where the confining unit may be uncharacteristically thin.
- Areas which may be associated with leakage through improperly abandoned boreholes.
- Areas identified during hydrologic testing as having hydraulic communication with the overlying or underlying aquifer.

An in-depth discussion of the positioning and spacing of monitoring wells is provided in Section 3.1.3 of this application.

3.1.1.1.1 Approach to Well Field Development with Respect to Historical Mine Workings

As described in Section 2.6.4.2 the former Darrow and Triangle open-pit mines and associated underground workings in the eastern portion of the project area extracted ore from the Fall River Formation. There are no underground mines within the project area that are not associated with, adjacent to, or extensions of the open pits, all of which are within the Upper Fall River Formation. These open-pit mines and underground workings did not penetrate the underlying Fuson Shale, which physically and hydraulically separates the Fall River from the underlying Chilson Member of the Lakota Formation across the entire project area.

Powertech (USA) will not conduct ISR operations in ore bodies in the Fall River in the vicinity of the Darrow and Triangle pits. Powertech (USA) proposes to conduct ISR operations within the Chilson in the general vicinity of this historic mine workings. Because of the physical and hydraulic separation of the Chilson from the overlying Fall River Formation, ISR operations in the Chilson will not affect the Fall River or create or enhance migration of constituents of concern from the open-pit or underground mines.

Figure 2.6-3a shows the spatial relationship between Powertech (USA)'s potential well fields and the historical mine areas. The location of underground workings in the vicinity of potential well field areas also is shown on Cross Section F-F' (Plate 2.6-12f). An examination of Figure 2.6-3a shows that Burdock Well Field 7 (B-WF7) underlies portions of the historical Darrow mine area. The targeted production zone for B-WF7 is the Lower Chilson.

As also shown on Figure 2.6-3a, Burdock Well Field 8 (B-WF8) is proposed below and horizontally adjacent to the surface expression of an area of past mining disturbance in Section 35, T6S, R1E. Excavation in this area was underway when the Edgemont mill was closed. This operation was on land owned by the Spencer family, and Donald Spencer (2011) related that all mining operations ceased before reaching the ore horizon. The pit was backfilled and reclaimed. Powertech (USA)'s targeted uranium recovery horizon for B-WF8 is the Lower Chilson. This unit is at least 200 feet beneath the base of the Fuson Shale and is well below the historical mining disturbance in the Fall River Formation.

As demonstrated in Section 2.6.4.2, neither the surface mining activity nor the shallow underground workings intersected or compromised the integrity of the underlying Fuson Shale confining unit. Cross section F-F' (Plate 2.6-12f) illustrates the continuous Fuson Shale confining unit throughout this area. In addition, outcrop examinations of the Fuson Shale in Bennett Canyon, ½-mile up-dip from the Darrow Mine area, reveal the presence of continuous, low-permeability mudstones and shales. The targeted resources in B-WF7 & B-WF8 are well confined and unaffected by historical mining activities in overlying horizons.

The potential effects of ISR operations in the Chilson on the overlying Fall River Formation will be evaluated further as part of the planned delineation drilling and well field-scale pumping tests prior to the development of each well field. Powertech (USA) also will install and sample operational monitor wells in the Fall River, Chilson, and alluvium between the open-pit mines and potential well field areas. For additional information, refer to Section 5.7.8.2.

The conditions that made the historical mining areas amenable to conventional surface and underground mining (e.g., shallow cover and unsaturated conditions) make these areas unattractive for ISR operations. Conversely, the areas proposed by Powertech (USA) for ISR operations are much too deep and contain too much water for them to have been affected by historical surface or underground mining activities.

3.1.1.1.2 Approach to Well Field Development with Respect to Partially Saturated Conditions

Refer to Section 2.7.2.2.2.3 for a description of partially saturated conditions. The only instance where hydrologically unconfined (partially saturated) conditions exist within an area that Powertech (USA) proposes for ISR operations occurs in the eastern portion of the project area. Powertech (USA) does not plan to conduct ISR operations in the Fall River on the eastern edge of the project area (in the vicinity of the Triangle or Darrow pits), where the Fall River is

geologically and hydrologically unconfined (partially saturated). However, Powertech (USA) proposes to conduct ISR operations in the underlying Chilson, which is confined above by the Fuson Shale and below by the Morrison Formation. As described in Section 2.6.2.2, the Fuson Shale has been identified and delineated by Powertech (USA) from geophysical logs for exploration holes and is more than 20 feet thick everywhere within the project area; the Fuson Member of the Lakota, which contains the Fuson Shale, is in aggregate 40 to 80 feet thick. Although the Chilson is not fully saturated near the eastern edge of the project boundary, the mineralization occurs near the base of the formation. As a result, any ISR operations will occur within the portion of the Chilson with available head sufficient for fluid control.

Within the project area, the Fall River Formation rises in elevation to the northeast. It subcrops on the eastern edge of the project area in the vicinity of the Darrow pits and crops out to the east in Bennett Canyon. In this area, the upper confining layer, namely the Graneros Group, is absent and the Fall River is geologically unconfined. Depending on location within this general area, the Fall River is partially saturated and the saturated thickness can be substantially less than 100 feet.

Similarly, the Chilson Member rises in elevation to the northeast and subcrops beneath the alluvium in Bennett Canyon. The potentiometric surface elevation for the Chilson is projected to be below the top of the formation on the eastern edge of the project area. Only in this limited area, the Chilson, although geologically confined by the overlying Fuson Shale, is partially saturated (i.e., the water table is below the top the formation). The projected limits for the fully saturated and partially saturated portions of the Fall River and the Chilson are shown on Figures 2.7-26 and 2.7-27, respectively.

Geologic cross section B-B' (Plate 2.6-12b) shows the potentiometric surfaces as well as the interbedded shales and siltstones within the Fall River and Chilson. The cross section depicts the location of the mineralization in the Chilson in relation to the Chilson potentiometric surface. Near the eastern portion of the project area the potentiometric surface is nearly 100 feet higher than the mineralization. Locally occurring shale units may serve to further confine the mineralization within the Chilson. As such, Powertech (USA) does not anticipate that ISR operations will occur where there is less than 50 feet of potentiometric head over the ore body.

After license issuance but prior to well field development, delineation drilling and well field pumping tests will be conducted to fully characterize the existing geologic and hydrogeologic conditions and to confirm sufficient head (>50 feet) is available to perform normal ISR operations. As an integral component of the characterization activities, a detailed evaluation will

be made, based on actual site conditions, regarding the application of ISR under partially saturated conditions should it be necessary. Partially saturated conditions, if encountered, would be similar in many respects to what has been licensed at Moore Ranch and will be addressed similarly with modeling.

3.1.2 Well Construction and Integrity Testing

Well construction materials, methods, development, and integrity testing are described in the following subsections.

3.1.2.1 Well Materials of Construction

Well casing material will typically be thermoplastic such as polyvinyl chloride (PVC). Wells typically will be 4, 5 and 6-inch nominal diameter, with wall thickness appropriate for design conditions. In order to provide an adequate annular seal, the drill hole diameter will be at least

two inches greater in nominal diameter than the outside diameter of the well casing. The annular seal will be pressure-grouted and sealed with either cement grout or bentonite grout.

Casing will be joined by fittings or using methods recommended by the casing manufacture.

3.1.2.2 Well Construction Methods

Typical well installation will begin with drilling a pilot bore hole through the ore zone to obtain a measurement of the uranium grade and the depth. The pilot bore hole will be geologically and geophysically logged. After logging, the pilot bore hole will be reamed to the appropriate diameter to the top of the ore zone. A continuous string of PVC casing will be placed into the reamed borehole. Casing centralizers will be installed as appropriate. With the casing in place a cement/bentonite grout will be pumped into the casing. The grout will circulate out the bottom of the casing and back up the casing annulus to the ground surface. The volume of grout necessary to cement the annulus will be calculated from the bore hole diameter of the casing with sufficient additional allowance to achieve grout returning to surface. Grout remaining inside the well casing may be displaced by water or heavy drill mud to minimize the column of the grout plug remaining inside the casing. Care will be taken to assure that at a grout plug remains inside the casing at completion. The casing and grout will then be allowed to set undisturbed for a minimum of 24 hours. When the grout has set, if the annular seal observed from the ground surface has settled below the ground surface, additional grout will be placed into the annular space to bring the grout seal to the ground surface.

After the 24-hour (minimum) setup period, a drill rig will be mobilized to finish well construction by drilling through the grout plug and through the mineralized zone to the specified total well depth. As illustrated in Figure 3.1-6, the open borehole will then be underreamed to a larger diameter.

A well screen assembly will then be lowered through the casing into the open hole. The top of the well screen assembly will be positioned inside the well casing and centralized and sealed inside the casing using "K" packers. With the drill pipe attached to the well screen, a one-inch diameter tremie pipe will be inserted through drill pipe and screen, and through the sand trap check valves at the bottom of well screen assembly. Filter sand, comprised of well rounded silica sand sized to optimize hydraulic communication between the target zone and well screen, will then be placed between the well screen and the formation. The volume of sand introduced will be calculated such that it fills the annular space. The sand will not extend upward beyond the K packers due to packer design. A well completion report will then be prepared for each

well. The reports will be kept available on-site for review. Copies will be submitted to regulatory agencies upon request.

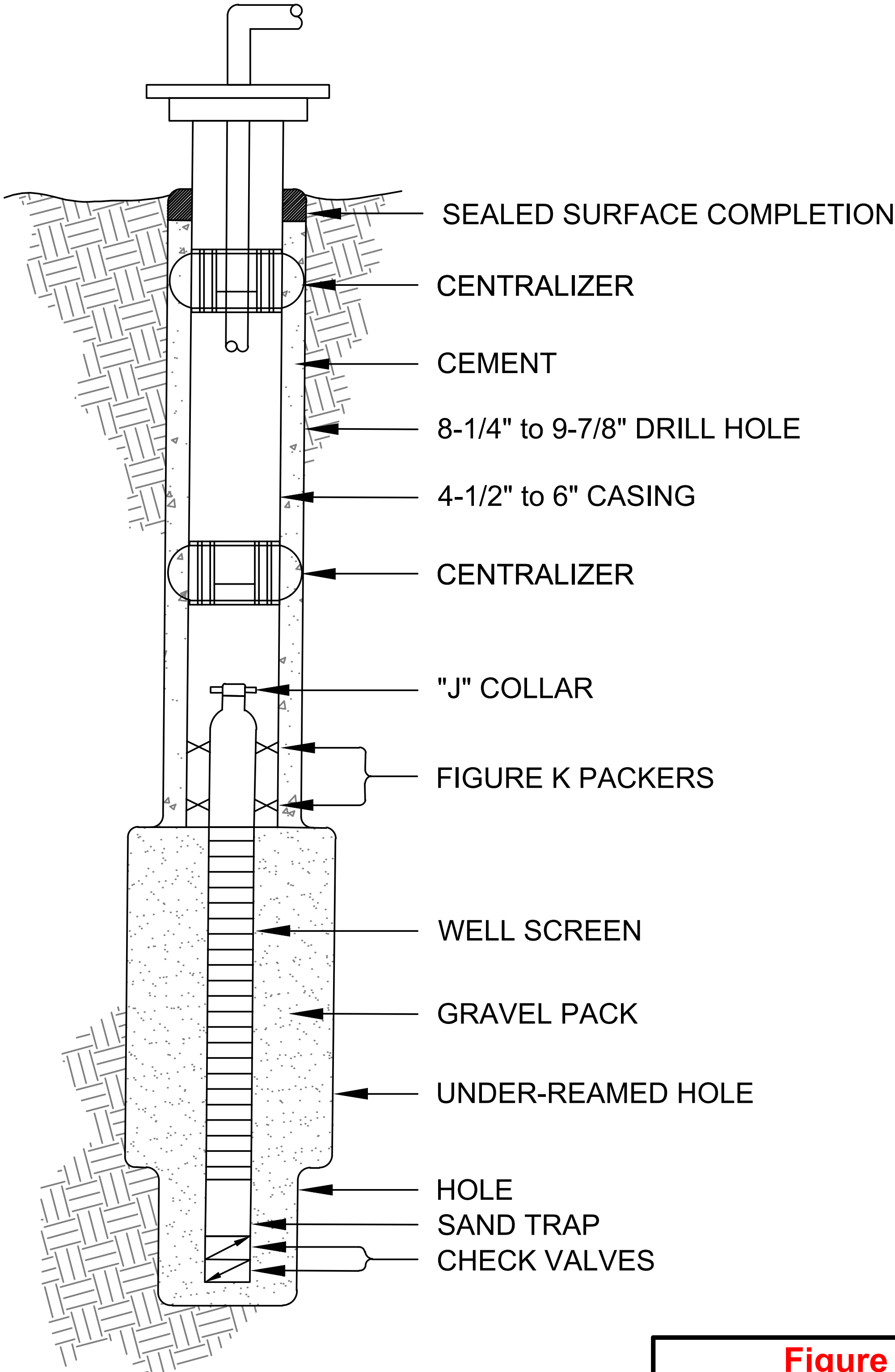

Figure 3.1-6

Typical Well Construction

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Wells-TypConstruction.dwg

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3.1.2.3 Well Development

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

3.1.2.4 Well Integrity Testing

Field-testing of all injection, recovery, and monitor wells will be performed to demonstrate the mechanical integrity of the well casing. The mechanical integrity test (MIT) will be performed using pressure-packer tests. The bottom of the casing will be sealed with a plug, downhole packer, or other suitable device. The casing will be filled with water and the top of the casing will be sealed with a threaded cap or mechanical seal. The well casing will then be pressurized with water or air and monitored with a calibrated pressure gauge. Internal casing pressure will be increased to 125 percent of the maximum operating pressure of the well field, 125 percent of the maximum operating pressure rating of the well casing (which is always less that the maximum pressure rating of the pipe), or 90 percent of the formation fracture pressure (which equates to approximately 1 psi per foot of overburden above the bottom of casing), whichever is less. A well must maintain 90 percent of this pressure for a minimum of 10 minutes to pass the test.

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

If a well casing does not meet the MIT criteria, the well will be removed from service. The casing may be repaired and the well re-tested, or the well may be plugged and abandoned.

Well plugging procedures are described in Section 5.7.1.3.4. If a repaired well passes the MIT, it will be employed in its intended service following demonstration that the well meets MIT criteria. If an acceptable test cannot be demonstrated following repairs, the well will be plugged and abandoned.

In addition to the integrity testing of new wells, a MIT will be conducted on any well following any repair where a downhole drill bit or under-reaming tool is used. Any injection well with evidence of suspected subsurface damage will require a new MIT prior to the well being returned to service. Mechanical integrity tests will also be repeated once every five years for all active wells.

The MIT of a well will be documented to include the well designation, date of test, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of the MITs will be maintained on-site and will be available for inspection by regulatory agencies. Results of MIT shall be reported within quarterly reports in accordance with the EPA UIC regulations in Title 40 Part 146.33.

3.1.3 Monitoring Well Layout and Design

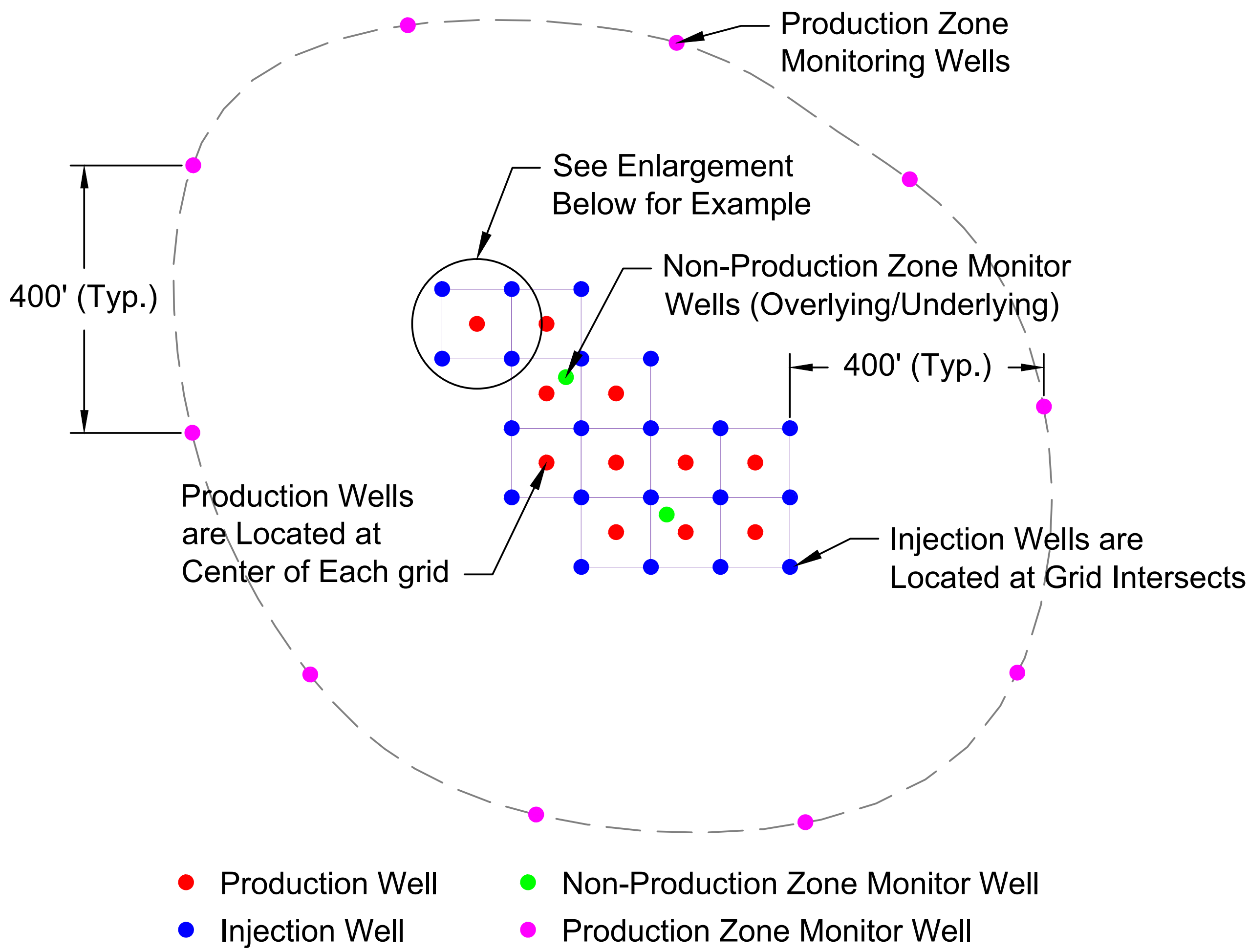
As discussed in Sections 5 and 6 of this application, an extensive groundwater sampling program specific to each well field will be conducted prior to, during, and following ISL operations to identify any potential impacts to water resources of the area. The groundwater monitoring program for individual well fields is designed to (1) establish baseline water quality prior to production, (2) detect excursions of lixiviant either horizontally or vertically outside the of the target mineralization zone, (3) demonstrate compliance with groundwater quality standards, and (4) determine when the mined mineralized zone has been adequately restored following ISL operations. Objectives 1 (partially) and 4 will accomplished using injection and recovery wells. Objectives 1 (partially), 2, and 3 will be accomplished using perimeter and internal non-production zone monitoring wells.

The production wells are laid out in a regular grid to efficiently contact the mineralized deposit (Figure 3.1-7). Generally, the wells are laid out in regular geometric shapes, usually squares, rectangles, triangles, or hexagons. The important features are that the patterns cover the economically mineable portions of the orebody, the production (pumping) well is in the center of

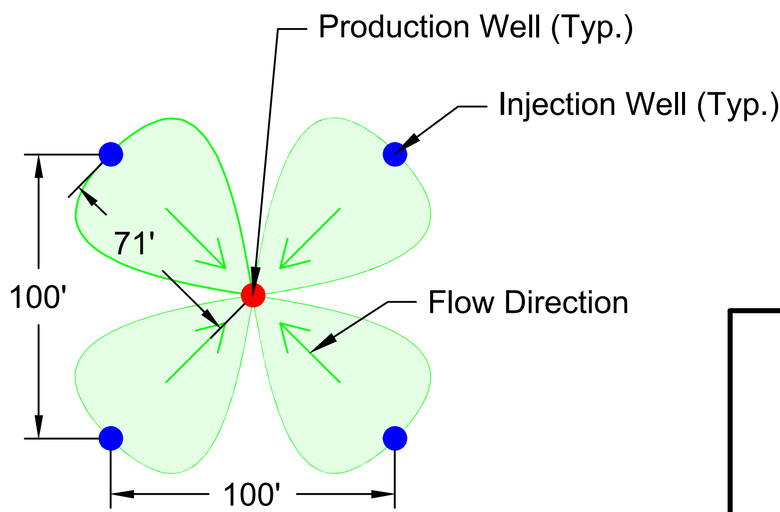
each geometric shape, the injection wells are equally spaced from each other and from the production wells in each pattern (geometric shape). This is to ensure efficient contacting of the ore by uniform flow distribution and to facilitate control of the flow to prevent excursion of lixiviant to the monitor well ring. The injection wells are on the outside to ensure the ore is contacted with lixiviant and a bleed withdrawing of some 0.5 to 3 per cent of the lixiviant circulating to maintain a cone of depression ensuring outside groundwater in the ore zone flows in toward the production well field to prevent flow of lixiviant outwards (NMA, 2007).

The production zone monitor wells are completed in the ore zone around the perimeter of the production well fields spaced 400 feet outside the production well field and evenly spaced around the perimeter of the well field with a maximum spacing either 400 feet or the spacing that will ensure a 70 degree angle between adjacent production zone monitor wells and the nearest injection well (NUREG/CR-6733; NUREG-1910, 2008; NUREG-1569). Justification for the perimeter monitor well spacing is found in Section 5.7.8.4.3.

Monitor well design will be included in the well field hydrogeologic data packages described in Section 3.1.3.3. Protection from surface water is described in Section 3.1.7. Adequate access to the monitor wells will be available even during infrequent storm events.



TYPICAL FIVE SPOT GRID PATTERN



Modified from Power Resources

Figure 3.1-7

Typical 5-Spot
Well Field Pattern

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	FiveSpotPattern.dwg

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3.1.3.1 Well Field Operational Monitoring

The primary purpose of a monitoring well is to serve as an early warning system for detection of excursions and to meet the operation point of compliance (POC) in accordance with NRC's interpretations of 10 CFR Part 40, Appendix A. The proposed monitoring system is described below.

3.1.3.1.1 Non-Production Monitoring Wells

Depending on-site specific conditions, non-production monitoring wells may consist of two types of monitor wells termed "overlying" and "underlying". The screened intervals of overlying wells are located in the sand units or aquifers above the ore-bearing stratum. The overlying non-production monitoring wells are designed to provide monitoring of any upward movement of lixiviant that may occur from the production zone and to guard against potential leakage from production and injection well casing into any overlying aquifer. The overlying and underlying wells are used to obtain baseline water quality data and are used in the development of UCLs for the overlying and underlying zones that will be used to determine if vertical migration of lixiviant is occurring. Vertical monitoring is generally set up with a density of wells ranging from one every three to five acres and where confining layers are very thick and permeabilities are negligible, requirements for vertical excursion monitoring can be relaxed or eliminated for underlying aquifers (NUREG/CR-6733, 2001). The screened zone for the overlying and underlying wells is determined from electric logs by qualified geologists or hydrogeologists.

<u>General Monitor Well Layout</u>

Monitor wells will be installed in each overlying aquifer. The term "overlying aquifer" refers to any hydrogeologic unit(s) above the production zone and separated by a confining layer. The terms "overlying aquifer" and "overlying hydrogeologic unit" are used interchangeably when describing well field operations in the project area. There may be more than one overlying hydrogeologic unit in a given well field, depending on the specific production zone and local geology. The presence or absence of local confining beds and the location of the production zone within the Fall River or Chilson will determine the number of overlying hydrogeologic units. At times, an alluvial unit may exist at the surface above the well field. This alluvial unit will be treated as an overlying hydrogeologic unit and monitored appropriately.

Monitor wells completed in the first overlying hydrogeologic unit will be designated with the prefix MO and will have a density of at least one well per 4 acres of well field pattern area. Subsequent overlying hydrogeologic units will have designations MO2, MO3, etc. and will have

a density of at least one well per 8 acres of well field pattern area. Monitor wells completed in the first underlying hydrogeologic unit will be named with the prefix MU and will have a density of one well per 4 acres of pattern area. Only the first underlying hydrogeologic unit will be monitored.

The internal, non-production zone monitor wells will be screened across the entire overlying and underlying aquifer to avoid missing an excursion (defined as when a monitor well sample contains more than two of the excursion indicators at the UCL level, in accordance with NUREG-1910, Supplement 1, pg. 4-2a) occurring above or below the screened interval.

The generalized monitoring scheme for the Fall River and Chilson is presented in Figure 3.1-8. This approach will be used when there are no substantial confining layers between ore bodies within the Fall River or Chilson.

At times local confining units within the Fall River and Chilson may be utilized in the monitoring scheme. The presence or absence of these will be confirmed with delineation drilling and mapped in more detail in the process of development of each well field hydrogeologic data package. The monitoring system also will be specified in each hydrogeologic data package (refer to Section 3.1.3.3). Should sufficient confining units be mapped after more detailed delineation drilling, the following describes how the well fields would be monitored. The following information represents a conceptual description of monitor well design for the initial Burdock and Dewey well fields.

Conceptual Monitor Well Layout – Initial Burdock Well Fields

Figure 3.1-9 shows the anticipated monitor well configuration for Burdock Well Fields 1 and 3. For B-WF1 the anticipated production zone will be the Lower Chilson, in which case the overlying hydrogeologic units would include the Middle and Upper Chilson and the Lower and Upper Fall River. Since the production zone in B-WF1 is anticipated to be in the lowermost Chilson hydrogeologic unit, which is underlain by the Morrison Formation, no monitoring would occur in the underlying hydrogeologic unit (Unkpapa). Section 3.1.3.1.1.1 contains additional explanation. The Middle Chilson, being the first overlying hydrogeologic unit, would be monitored at a density of one well per 4 acres with monitor wells designated MO. Monitor wells would be completed in the Upper Chilson, the Lower Fall River, and the Upper Fall River at a density of one well per 8 acres in each unit. These wells would be designated MO2 (Upper Chilson), MO3 (Lower Fall River) and MO4 (Upper Fall River). For B-WF3, the anticipated

production zone will be the Upper Chilson, in which case the first overlying hydrogeologic unit would be the Lower Fall River (monitor wells at one per 4 acres and designation MO) and the second overlying unit would be the Upper Fall River (monitor wells at one per 8 acres and designation MO2). For B-WF3 the Middle Chilson would be the underlying hydrogeologic unit and would be monitored at a density of one well per 4 acres of pattern with designation MU.

Figure 3.1-10 depicts the type log for B-WF1. This type log illustrates the various hydrogeologic units that Powertech (USA) anticipates monitoring in B-WF1 as described above.

In some cases, the production zone of one well field will be in the immediately overlying hydrogeologic unit of another well field. Monitoring for all hydrogeologic units will be continued in the same fashion as described above with the exception that the overlying monitor wells will be excluded from the production zone of an immediately overlying well field. This will only occur inside the perimeter well ring of the overlying well field.

As an example, Figure 3.1-9 shows the monitoring configuration of a production zone in the Upper Chilson in the Burdock area, B-WF3. When this well field is developed, there could be some MO2 wells in the Upper Chilson associated with a previous well field developed in the Lower Chilson within its perimeter monitor ring. When injection is started, use of these former MO2 wells for monitoring will cease. However, all other monitor wells for the Upper Fall River, Lower Fall River, Upper Chilson, and Middle Chilson associated with B-WF1 will remain in use.

Conceptual Monitor Well Layout – Initial Dewey Well Fields

Figure 3.1-11 shows the anticipated monitoring well configuration for the initial Dewey well fields. For D-WF1 the anticipated production zone will be the Lower Fall River, in which case the MO zone (with monitoring at one well per 4 acres) would be the Upper Fall River, and there would be no additional overlying hydrogeologic units. The MU zone (with monitoring at one well per 4 acres) would be the Upper Chilson. Similar conventions are shown for D-WF2 and D-WF3.

Figure 3.1-12 depicts the type log for D-WF1. This type log depicts the various hydrogeologic units that Powertech (USA) anticipates monitoring as described above.

Conclusion

During the ongoing well field development, the monitor well designations may change. However, the density of monitor wells in the overlying hydrogeologic units will remain as discussed above. Development of each well field monitoring system will be included in the hydrogeologic data packages prepared during the detailed design of each well field. Hydrogeologic data packages, including pump testing procedures used to establish that the injection wells are hydraulically isolated from vertical monitor wells, are described in Sections 3.1.3.2 and 3.1.3.3.

By properly designing and pump testing each well field and its associated monitor well network, including specifically addressing those areas having the greatest potential for excursions, Powertech (USA) will minimize the risk of excursions and minimize the potential impacts resulting from excursions. By routinely sampling monitor wells for changes in water level and concentrations of the highly mobile and conservative excursion parameters of chloride, total alkalinity and conductivity, Powertech (USA) will ensure that any potential excursions are identified and corrected quickly. As described on page B-75 of the Moore Ranch Final SEIS (NUREG-1910, Supplement 1, Appendix B), "An excursion is defined as an event where a monitoring well in overlying, underlying, or perimeter well ring detects an increase in specific water quality indicators, usually chloride, alkalinity and conductivity, which may signal that fluids are moving out from the wellfield…The perimeter monitoring wells are located in a buffer region surrounding the wellfield within the exempted portion of the aquifer. These wells are specifically located in this buffer zone to detect and correct an excursion before it reaches a USDW…To date, no excursion from an NRC-licensed ISR facility has contaminated a USDW."

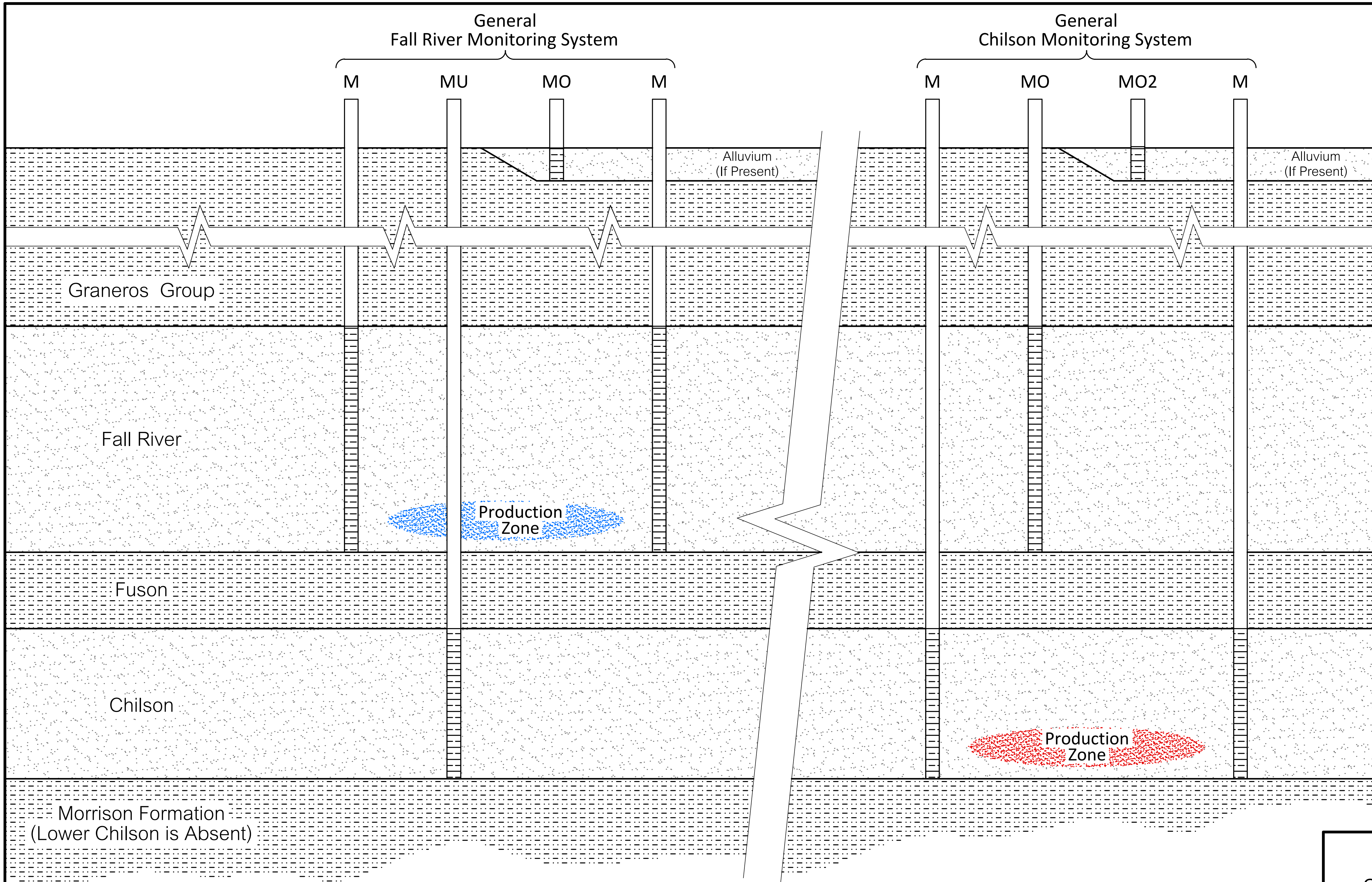
Additional information about sampling parameters, frequencies, and procedures is provided in Section 5 of this application.

3.1.3.1.1.1 Monitoring the Unkpapa Sandstone

The Unkpapa Sandstone is considered the first aquifer below the Morrison Formation, a regional confining unit 60 to 140 feet thick throughout the project area. The Unkpapa will be the underlying aquifer when there is not a suitable or distinct hydrogeologic unit within the Chilson (such as the Lower Chilson sand) below a production zone. For production zones in the lowest portion of the Chilson, the Unkpapa will be the underlying aquifer.

Excursion monitoring will not occur in the Unkpapa. The justification for not performing excursion monitoring is as follows:

1) The Unkpapa Sandstone shows substantially higher potentiometric head than the Fall River and Chilson throughout the project area. During ISR operations, the potentiometric head will be reduced (creating a cone of depression) in the Chilson and Fall River due to a net withdrawal (production flow greater than injection flow) in order to maintain well field bleed. Flow into the Unkpapa from production zones in the Fall River and Chilson operating at a substantially lower potentiometric head would be impossible.
2) The Morrison Formation is prevalent across the entire project area and will act as an aquitard to prevent flow into the Unkpapa from the Fall River and Chilson. This was demonstrated by the pumping tests conducted by Powertech (USA), where no response occurred in the Unkpapa during pumping of either the Fall River or Chilson.
3) The Unkpapa is a low-yield aquifer determined by a recent water supply well installation by Powertech (USA). Water samples from the Unkpapa can no longer be obtained from well 704 because this well was cemented off in the Unkpapa in 2009 and perforated in the Chilson due to low yield from the Unkpapa.



M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2 - Monitor Overlying Sand (1 per 8 acres)

Production Zone Legend
Fall River
Chilson

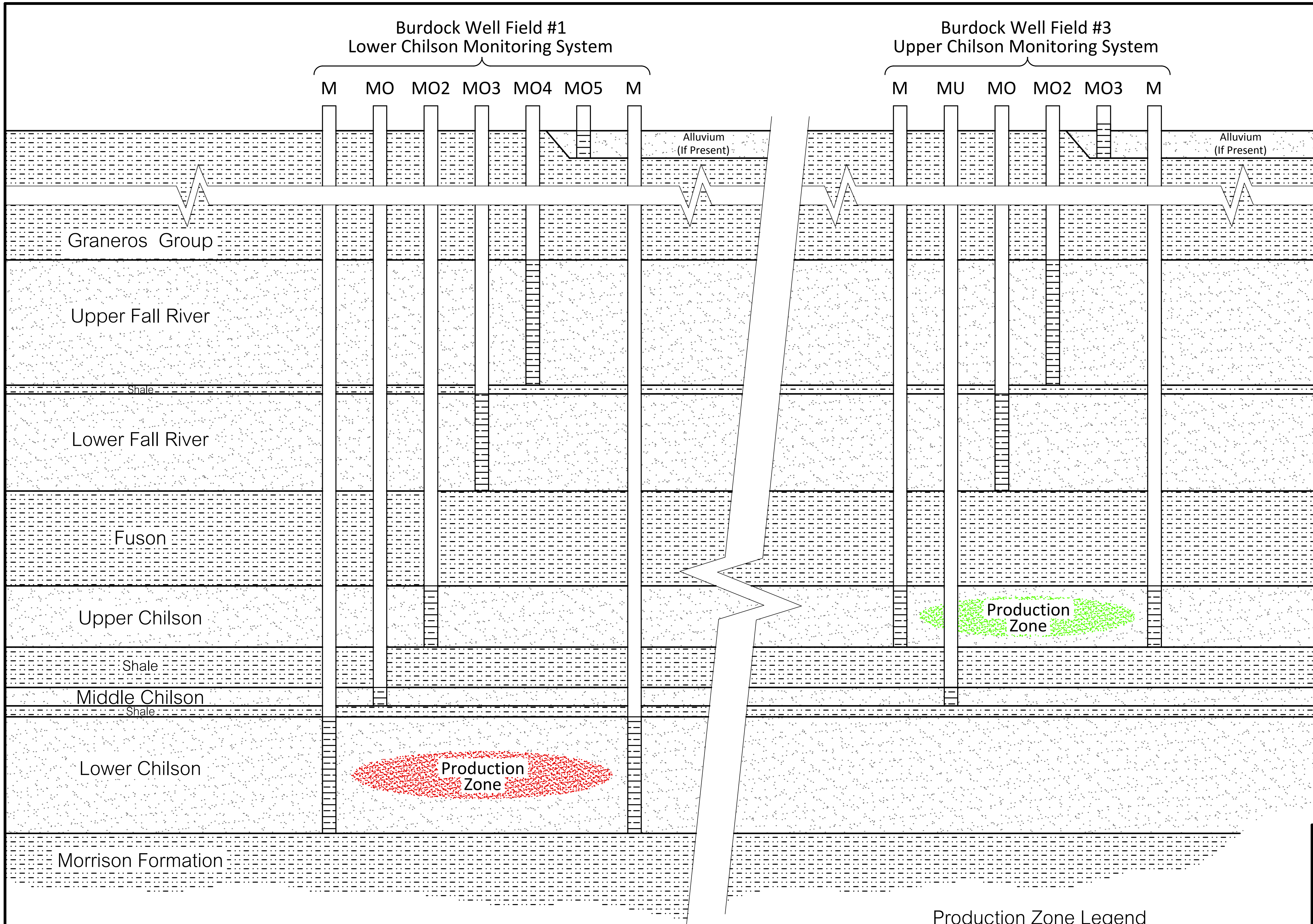
Figure 3.1-8

Generalized Monitor Well Configuration

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	MonWell-GenConf.dwg

Powertech (USA) Inc.



M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2, MO3, MO4, MO5 - Monitor Overlying Sand (1 per 8 acres)

Figure 3.1-9

Anticipated Burdock Monitor Well Configuration

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	MonWell-BurdConf.dwg

POWERTECH (USA) INC.

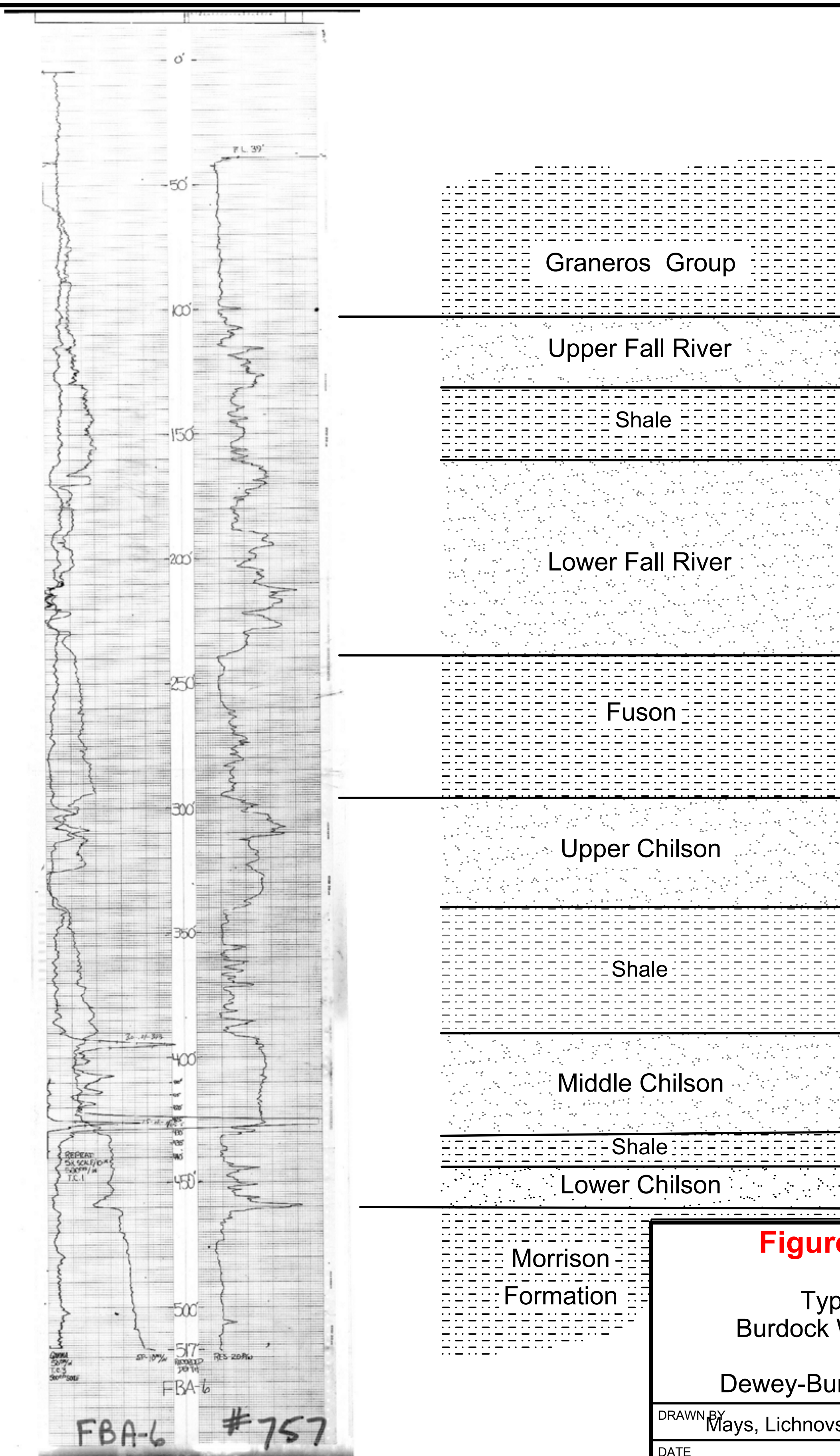


Figure 3.1-10

Type Log
Burdock Well Field 1

Dewey-Burdock Project

DRAWN BY	Mays, Lichnovsky
DATE	17-Jun-2013
FILENAME	WF-B1-TypeLog.dwg

POWERTECH (USA) INC.

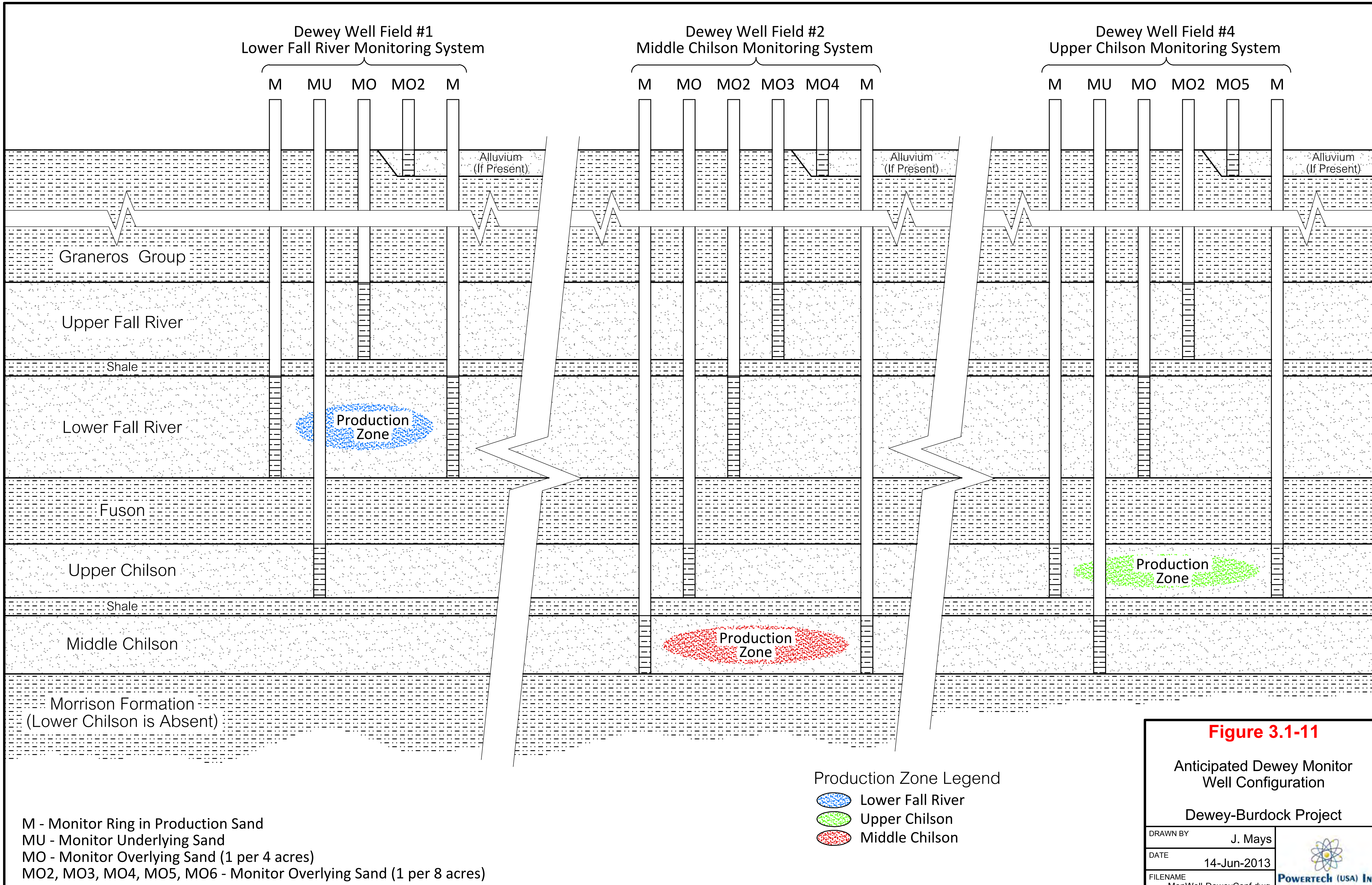


Figure 3.1-11

Anticipated Dewey Monitor Well Configuration

Dewey-Burdock Project

DRAWN BY J. Mays

DATE 14-Jun-2013

FILENAME MonWell-DeweyConf.dwg

Powertech (USA) Inc.

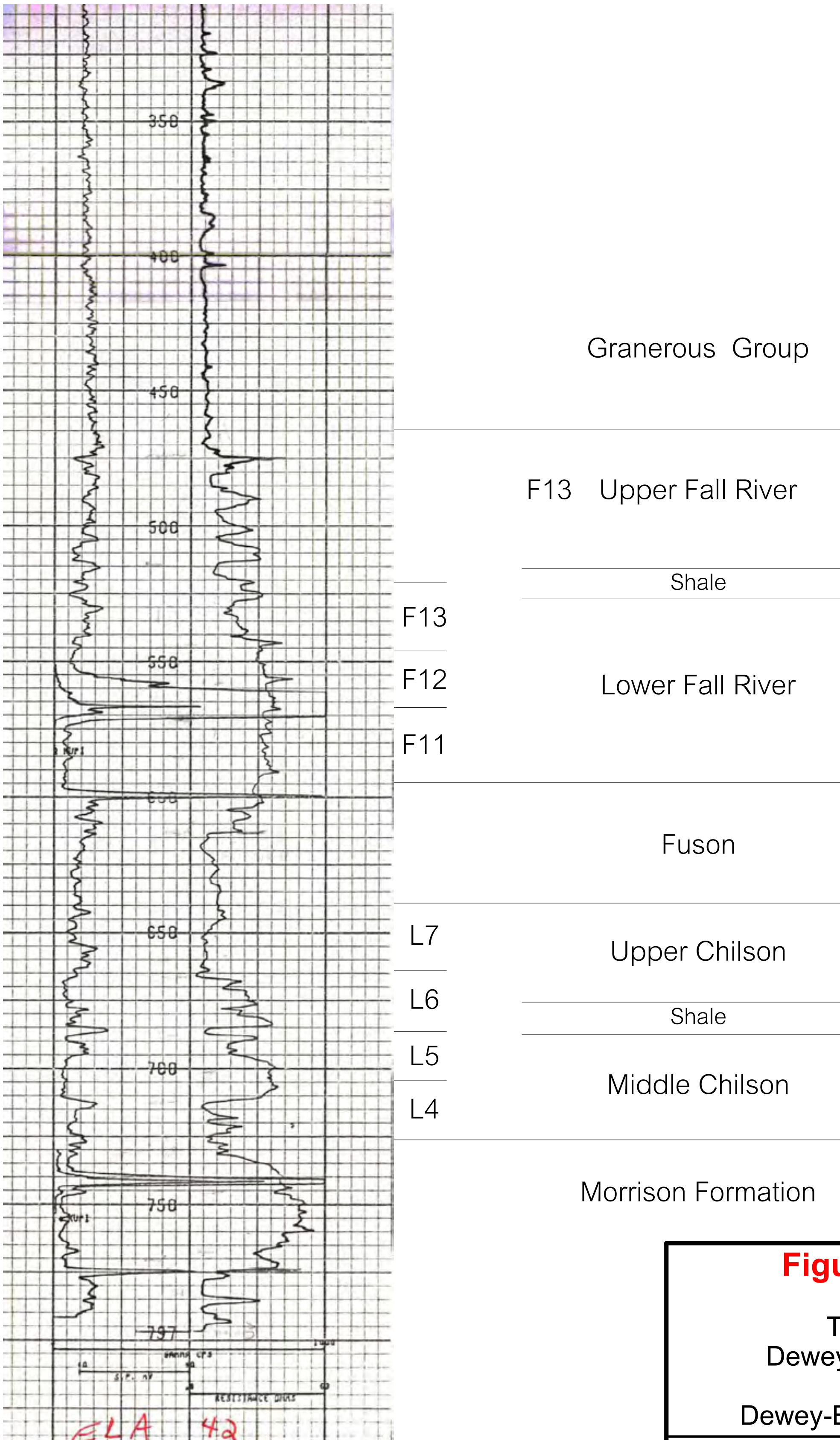


Figure 3.1-12

Type Log
Dewey Well Field 1

Dewey-Burdock Project

DRAWN BY	Bonner,Lichnovsky
DATE	17-Jun-2013
FILENAME	WF-D1-TypeLog.dwg

POWERTECH (USA) INC.

3.1.3.1.2 Production Monitoring Wells

Production zone monitoring wells are installed around the periphery of each production area to monitor for any fluids that might escape the hydraulic controls (Hunkin, G. G., 1977 and Dickinson, K. A., and J. S. Duval, 1977), with a screened interval open to the sand unit containing the production zone. This monitoring “ring” design serves two purposes: (1) to monitor any horizontal migration of fluid within the sand unit or aquifer where production is occurring and, (2) to determine baseline water quality data and characterize the area outside the production pattern area. Upper Control Limits (UCLs) are determined from indicator constituents that are selected due to their nature of mobility to provide early warning with regards to a potential excursion; these constituents will be chloride, total alkalinity, and conductivity. By establishing UCLs, the operator is allowed the capability of early detection of an excursion at a monitor well and then has the time to apply corrective action before water quality outside the aquifer exemption boundary is adversely affected (NUREG/CR-6733, 2001). Production zone monitor wells will be located no more than 400 feet from the production area, and will be spaced no more than 400 feet between production zone monitoring wells (NUREG/CR-6733; NUREG-1910, 2008; NUREG-1569). If the monitor wells are closer than 400 feet to the well field, the monitor wells will be located via a strategic distance to maintain a minimum angle between monitor wells and the nearest injection well of 70 degrees. This will ensure that no lixiviant will pass between the adjacent monitor wells undetected as the lixiviant would flow radially outward from the initiation point of an excursion. Justification for the perimeter monitor well spacing is found in Section 5.7.8.4.3. Production zone monitoring wells are installed before the start of production activities in order that required baseline sampling and hydrologic tests can be conducted. Well design, construction, and development will be identical to those of injection and recovery wells, except well screens will be completed across the entire mineralized sandstone as described below (Figure 3.1-6). Additional information about sampling parameters, frequencies, and procedures is provided in Section 5 of this application.

Consistent with NUREG-1569 (page 5-42), the perimeter monitor wells will be screened across the entire thickness of the production zone, which will be determined following completion of delineation drilling for each well field. In all cases, the screens will fully penetrate the hydrogeologic unit to be monitored, i.e., spanning the entire interval between the overlying and underlying confining beds. As described in Section 2.6, the Fuson Shale is pervasive throughout

the project area and forms a confining unit between the Fall River and Chilson. No monitor well will be screened across the Fuson Shale and into the Fall River and Chilson.

In some areas, multiple ore bodies are vertically stacked within the Fall River or Chilson. The perimeter production zone monitor wells will be screened across the full thickness of the hydrogeological unit (Fall River or Chilson, but not both), and these multiple ore bodies treated as a single production zone for the purpose of determining the horizontal distance between the production zone and the monitor well ring. This approach will be utilized when there are no substantial confining layers between ore bodies within the hydrogeologic unit (Fall River or Chilson) and when the hydrogeologic unit containing the multiple ore bodies behaves as a single hydraulically connected unit. An example of this type of monitoring approach is shown in Figure 3.1-8.

In the case where a localized confining unit (other than the Fuson Shale) is present between stacked ore bodies within one of the primary hydrogeologic units (Fall River or Chilson), the monitoring approach may be modified such that perimeter monitor wells are screened only within the portion of the hydrogeologic unit in which the ore body is located. An example of this approach is described as follows. Based on characterization to date, the Chilson has been subdivided into three subunits: Upper Chilson, Middle Chilson, and Lower Chilson. In some cases, a low-permeability unit separates the Upper Chilson from the Middle and Lower Chilson. This relationship is shown on the geologic cross sections (Plates 2.6-12a through 2.6-12h and 2.6-12j). If it is demonstrated that the localized confining unit provides hydraulic separation between the Upper Chilson and the lower units of the Chilson, then monitor wells will be located and designed to monitor these zones separately as shown on Figures 3.1-9 and 3.1-11. Using this approach, if the ore body were located within the Upper Chilson unit, the perimeter monitor wells will only be screened across the Upper Chilson.

In places where there is no confining layer between the Middle and Lower Chilson and they become a single hydrogeologic unit, then these will be treated as one unit for purposes of monitoring. If they are separate units within the entire area of the perimeter monitor ring of the well field, then they will be treated as separate hydrogeologic units and monitored separately.

The screened intervals for the perimeter monitor wells will be further justified by demonstrating responses to pumping during the well field-scale pumping tests (see Section 3.1.3.2). Numerical modeling will also be conducted to further evaluate the likely magnitude of the response in the perimeter monitor wells to ISR operations.

3.1.3.2 Pump Testing

The following pump testing procedures will be used to establish that the production and injection wells are hydraulically connected to the perimeter production zone monitor wells, that the production and injection wells are hydraulically isolated from non-production zone vertical monitor wells, and to detect potentially improperly plugged wells or exploration holes. In the event that a well is located, it will be evaluated and, if necessary, reported to SERP and mitigated following the procedures described in Section 5.7.1.3.4. Pump testing results will be included in the well field hydrogeologic data package described in Section 3.1.3.3.

<u>Pump Testing Design</u>

An extensive pump test program will be designed and implemented prior to operation of each well field to evaluate the hydrogeology and assess the ability to operate the well field. Prior to pump testing several important well field development steps will be completed:

1) Delineation drilling at a spacing approximately equivalent to well field pattern size. As standard procedure, all delineation holes will be plugged and abandoned after drilling.
2) Detailed mapping of the ore bodies targeted for ISR operations and the lithology of overlying and underlying sand units and aquitards.
3) Revision of the conceptual geology and hydrogeology including definition of aquitards and sand units to be produced or monitored.
4) Design of the production and injection wells including well locations and screened intervals.
5) Design of the monitor well system based on production and injection well locations and refined conceptual geology and hydrogeology.
6) Specification of all monitor well locations and screened intervals.
7) Installation of all monitor wells and production wells used during pump testing.
8) Plugging and abandoning all water supply wells within ¼ mile of the well field or that have been determined through preliminary evaluation to be potentially impacted by ISR operations or to impact ISR operations.

Pump Testing Procedures

The entire monitoring system for the well field will be monitored during the pumping test, including but not necessarily limited to the following wells:

1) Pumping wells,
2) Monitor wells within the production zone (at a minimum density of 1 per 4 acres),
3) Perimeter production zone monitor wells,
4) Monitor wells in the immediately overlying non-production zone sand unit (at a minimum density of 1 per 4 acres),
5) Monitor wells in each subsequently overlying non-production zone sand unit (at a minimum density of 1 per 8 acres),
6) Monitor wells in the alluvium, if present (at a minimum density of 1 per 8 acres),
7) Monitor wells in the immediately underlying non-production zone sand unit, if the production zone does not occur immediately above the Morrison Formation (at a minimum density of 1 per 4 acres),
8) Any additional wells installed for investigating other hydrogeologic features, and
9) Any other wells within proximity to the well field that have been identified as having the potential to impact or be impacted by ISR operations.

All monitoring system wells will be monitored using downhole data logging pressure transducers, which will be corrected for variations in barometric pressure.

Prior to testing, static potentiometric water levels will be measured in every well in the monitoring system. These data will be used to map the preoperational potentiometric surface for each unit including alluvium, where present. Because of the high density of wells and artesian conditions at the site, any leakage across aquitards due to improperly plugged boreholes or wells will typically become apparent while preparing potentiometric surface maps. Four water samples will be collected from each monitor well and analyzed for the parameters. The water quality will be evaluated to identify any potential areas of leakage across aquitards due to improperly plugged boreholes or wells.

Pump testing will involve inducing stress on the production zone sand unit by operating pumping wells. The goal of the test will be to cause drawdown in the production zone extending to all perimeter monitor wells. More than one pumping well may be required to create drawdown in all perimeter monitor wells. Pump testing will create a cone of depression across the well field area to test the confinement between the production zone and the overlying and underlying sand units

and alluvium, if present. The pump tests will specifically be designed to address potential leakage through confining units through improperly sealed or unplugged exploration boreholes, or associated with naturally occurring geologic features. The presence or lack of response in vertical monitor wells will be used for evaluation of confinement between these units and for identification of leakage due to anomalies such as improperly plugged boreholes. If leakage is present, the relative responses in the overlying, underlying, and/or alluvial monitor wells will indicate the proximity and direction towards the source of leakage.

If saturated alluvium is present within the well field, alluvial monitor wells will be installed and monitored above the production zone and within an appropriate distance from the well field. The water level in the alluvium will be mapped prior to testing and monitored during pump testing. If the potentiometric surface of the production zone unit rises above the base of the alluvium, pump testing will create sufficient drawdown to lower the production zone unit potentiometric surface below the lowest elevation of the alluvium in the well field. If there are anomalous conditions that cause communication between the production zone and alluvium such as an improperly plugged borehole, these conditions will be identified through responses in the alluvial monitor wells.

The pumping test duration will be sufficient to create a suitable response in the perimeter monitor wells. Typically, this will be a minimum drawdown of 1 foot in each perimeter monitor well. If hydrogeologic conditions dictate, less response may be justified.

The flow rate of the pumping test will be greater than or equal to the maximum well field bleed or the maximum expected flow rate of a single production well, whichever is greater.

Measurements during pump testing will include instantaneous and totalized flow, continuous pressure transducer measurements, barometric pressure, and time. A step rate test will be performed initially. There will be an initial stabilization phase with no flow, a stress period of constant flow, and a recovery period with no flow. During the entire test downhole pressure transducers will collect data in each monitor well.

<u>Pump Test Evaluation</u>

Evaluation of pump test data will address the following:

1) Demonstration of hydraulic connection across the production zone and between the production and injection wells and all perimeter monitor wells.
2) Confirmation that all monitor wells can suitably detect an excursion.

3) Verification of the geologic conceptual model for the well field.
4) Evaluation of the vertical confinement and hydraulic isolation between the production zone and overlying and underlying units.
5) Demonstration that solutions can be controlled with a typical well field bleed.
6) Calculation of the hydraulic conductivity, storativity, and transmissivity of the production zone sand unit.
7) Evaluation of anisotropy within the production zone sand unit.
8) Calculation of anticipated drawdown during ISR operation at typical bleed rates.
9) Detection of potentially improperly plugged wells or exploration boreholes.

3.1.3.3 Well Field Hydrogeologic Data Packages

Pumping test data and results will be included in the Well Field Hydrogeologic Data Packages. Upon completion of field data collection and laboratory analysis, the Well Field Hydrogeologic Data Package will be assembled and submitted for review by the Safety and Environmental Review Panel (SERP) for evaluation. The SERP evaluation will determine whether the results of the hydrologic testing and the planned ISR operations are consistent with standard operating procedures and technical requirements stated in the source and byproduct material license. The evaluation will include review of the potential impacts to human health and environment. If anomalous conditions are present or the SERP evaluation indicates potential to impact human health or the environment, the Well Field Hydrogeologic Data Package will be submitted to NRC for review and approval. Otherwise, the Well Field Hydrogeologic Data Package and written SERP evaluation will be maintained at the site and available for NRC review.

A Well Field Hydrogeologic Data Package will contain the following:

1) A description of the proposed well field (location, extent, etc.).
2) Map(s) showing the proposed production and injection well patterns and locations of all monitor wells.
3) Geologic cross sections and cross section location maps.
4) Isopach maps of the production zone sand and overlying and underlying confining units.
5) Discussion of how pump testing was performed, including well completion reports.
6) Discussion of the results and conclusions of the pump testing, including pump testing raw data, drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps and, when appropriate, directional transmissivity data and graphs.

7) Sufficient information to show that wells in the monitor well ring are in adequate communication with the production patterns.
8) Baseline water quality information including proposed UCLs for monitor wells and target restoration goals (TRGs).
9) Any other information pertinent to the proposed well field area tested will be included and discussed.

3.1.4 Hydraulic Well Field Control

Powertech (USA) will maintain hydraulic control of each well field from the first injection of lixiviant through the end of aquifer restoration. During uranium recovery, the groundwater removal rate in each well field will exceed the lixiviant injection rate, creating a cone of depression within each well field. During aquifer restoration, the groundwater removal rate in each well field will exceed the injection rate of permeate and clean makeup water from the Madison Formation or another suitable formation. If there are any delays between uranium recovery and aquifer restoration, production wells will continue to be operated as needed to maintain water levels within the perimeter monitor rings below baseline conditions. This activity may be intermittent or continuous.

Verification of hydraulic control will be performed through water level measurements in perimeter monitor wells. Water levels will be measured continuously using pressure transducers and recorded at a frequency appropriate to confirm hydraulic well field control. Other standard operating procedures to monitor and control well field operations are described in Sections 3.1.5 and 3.2-12.

3.1.5 Detection and Cleanup of Piping Leaks

Leak detection will be performed by daily visual inspection of all above-ground pipe, connections, and fittings by field personnel during their daily site visits. Operating pressures of all injection wells, recovery wells, and associated buried piping systems will also be monitored during these visits. In addition, the pressure and flow in each line will be monitored. Should pressure/flow fluctuate outside of "normal" operating ranges, the affected line will be shut down. An operator will then inspect the troubled component and determine the source of the problem. The troubled component will then be repaired, tested, and returned to service, as appropriate, and preventative measures will be implemented to prevent a recurrence.

Cleanup will involve characterizing the extent of release via visual observation coupled with sampling of soils for constituents of concern in accordance with a standard operating procedure. To the greatest extent practicable, impacted material will be consolidated into a centralized area to mitigate the potential for proliferation of small waste disposal sites within the license area. More information regarding spill management is presented in Subsection 5.7.1.3 (Spill Provision Plans) of this application.

3.1.6 Liquid Waste Disposal System Design

Powertech (USA) proposes two methods for disposal of liquid waste at the PAA. These include deep disposal well and land application. The following sections describe the design of the land application system, deep disposal wells, and associated ponds. Section 4.2.2.4 provides additional details regarding liquid waste disposal, including water balance figures.

3.1.6.1 Pond Design

The total pond area proposed for the land application option is approximately 71 acres. The land application system will occupy around 760 acres; however, only 630 acres will typically be used at one time. The rest will be on standby. These values are based on the most current design of the land application system. Appendix 3.1-A provides pond design information for both liquid waste disposal options. The pond design is summarized below. Section 3.1.6.1.1 provides detailed descriptions of pond sizing calculations.

Land Application

The land application disposal option will include the following ponds:

- **Two (2) Radium Settling Ponds** - one near each land application area (Dewey and Burdock). Each pond will have an operating capacity of 39.4 acre-feet. Radium settling ponds for the land application disposal option were designed such that a single pond has sufficient capacity for radium removal of the entire project-wide wastewater stream at the maximum expected production bleed of 3% while maintaining a minimum retention time of 14.1 days.
- **Two (2) Spare Ponds** - one at each area. Each pond will have an operating capacity of 39.4 acre-feet. The spare ponds will be designed with the same dimensions and liner system as the radium settling ponds so that they can be used as either spare radium settling ponds or spare Central Plant Ponds.
- **Two (2) Outlet Ponds** - one at each area. Each pond will have an operating capacity of 4.9 acre-feet. The outlet ponds will be designed to temporarily store treated water from the radium settling ponds and provide extra capacity for the radium settling ponds during large precipitation events.
- **Eight (8) Storage Ponds** - four at each area. Each pond will have an operating capacity of 63.8 acre-feet. The storage ponds will be used to store treated water during the winter months when no liquid waste disposal by land application systems is available. The total storage required at each area was obtained using the SPAW model, which is discussed in more detail in the Pond Design Report (Appendix 3.1-A) and in Section 4.2.2.1.
- **Two (2) Spare Storage Ponds** - one at each area. Each pond will have an operating capacity of 63.8 acre-feet. The spare storage ponds will be designed with the same dimensions and liner system as the storage ponds so that they can be used in the event of an upset condition.
- **One (1) Central Plant Pond** - located at the Burdock CPP, with an operating capacity of 36.2 acre-feet. The storage capacity design for the Central Plant Pond allows for over 18 months of CPP liquid waste storage, which will be required during initial uranium recovery operations when no groundwater sweep water is available to blend with CPP liquid waste.

Deep Disposal Well

The deep disposal well liquid waste disposal option will include the following ponds:

- **Two (2) Radium Settling Ponds** - one at each area. Each pond will have an operating capacity of 15.9 acre-feet. Radium settling ponds for the DDW option were designed such that a single pond has sufficient capacity for radium removal of the entire project-wide liquid waste stream at the maximum expected production bleed of 3% while maintaining a minimum retention time of 12.7 days.

- **Two (2) Spare Ponds** - one at each area. Each pond will have an operating capacity of 15.9 acre-feet. The spare ponds will be designed with the same dimensions and liner system as the radium settling ponds so that they can be used as either spare radium settling ponds or spare Central Plant Ponds.
- **Two (2) Outlet Ponds** - one at each area. Each pond will have an operating capacity of 5.1 acre-feet. The outlet ponds will be designed to temporarily store treated water from the radium settling ponds and provide extra capacity for the radium settling ponds during large precipitation events.
- **Two (2) Surge Ponds** - one at each area. Each pond will have an operating capacity of 8.4 acre-feet. The surge ponds will provide surge capacity for treated liquid waste flowing out of the radium settling ponds. They have been sized to accommodate 7 days of water production.
- **One (1) Central Plant Pond** - located at the Burdock CPP, with an operating capacity of 15.9 acre-feet.

All ponds have been designed to accommodate the design flows of liquid waste plus the precipitation from the 100-year precipitation event, while maintaining 3 feet of freeboard.

In the event that both deep disposal wells and land application are used, the pond capacity will be in between the two sizes discussed above.

Seismic stability analyses for the pond designs are discussed in Sections 3.11.4 and 3.11.5 of the Dewey-Burdock Pond Design Report (Appendix 3.1-A), which concludes, “The factors of safety indicate that the inner and outer slopes are stable under static and maximum credible earthquake seismic loading conditions.”

3.1.6.1.1 Pond Sizing and Sludge Accumulation

Radium Settling Ponds

Powertech (USA) has designed the radium settling ponds for a project life extending well beyond 10 years. The radium settling ponds have been sized conservatively in that each pond has been designed to process the entire project-wide liquid waste stream with a minimum retention time of approximately 13 days at the maximum production bleed rate of 3%. In actual practice, the production bleed will typically be about 0.875% and the liquid waste will typically be divided between the Dewey and Burdock radium settling ponds. Higher bleed rates, up to 3%, will only be used for relatively short time periods as needed to control the sub-surface movement of lixiviant.

The inputs to the radium settling pond retention times and sludge accumulation rate calculations are presented in Table 3.1-2. The Pond Design Report is provided as Appendix 3.1-A.

The Dewey-Burdock Project is expected to produce liquid waste from project year 2 through the first quarter of project year 10, for a total of 8.25 years. Table 3.1-3 shows estimates of the production bleed and liquid waste produced from uranium recovery, aquifer restoration and CPP operations. The estimated production bleed and CPP wastewater volume were calculated based on estimates of the volume of barren lixiviant required to recover U_3O_8 at the Dewey-Burdock Project. The restoration waste volumes were calculated assuming 6 pore volumes of restoration composite. This table also shows the design values for the total volume of sludge accumulated and the computed mean pond retention times for both the deep disposal well and land application disposal options at the typical production bleed rate of 0.875%. The pond retention times were computed both for initial ISR operations, when no sludge will have accumulated, and at project end, when the liquid retention time will be reduced due to accumulated sludge, which will reduce the available pond volume. Additionally, pond retention times were computed for extended periods of operation, including 10 and 20 years of ISR operation. In order to calculate the volumes of liquid waste for computing the sludge accumulation and retention times after 10 and 20 years of operations, the typical liquid waste flow rates for uranium recovery with concurrent aquifer restoration were used. These values are 547 gpm for the land application option and 197 gpm for the deep disposal well option (see Sections 4.2.2.1 and 4.2.2.2, respectively). This results in a very conservative estimate of the volume of sludge accumulation and subsequent reduction in retention pond capacity because it is very unlikely that these flow rates would be sustained for 10- or 20-year periods. The volumes of sludge presented in Table 3.1-3 were computed based on the addition of barium chloride at a rate of 20 mg/L of wastewater and assuming the pond sludge is comprised of the resultant barium sulfate, with a solids content of 40 percent by weight and a specific gravity of 1.4. These values are considered to be conservative.

As shown in Table 3.1-3, the volume of sludge which will accumulate over 10- and 20-year periods is relatively small compared to the overall pond volume. For example, after 20 years of pond operation at the typical production bleed of 0.875%, the estimated volume of accumulated sludge is 0.25 ac-ft for the deep disposal well option and 0.71 ac-ft for the land application option, which reduces the liquid retention time in the ponds by approximately 0.3 day, a reduction of less than 2% of the initial pond retention time. The resulting retention time after 20 years is estimated to be 16 to 18 days, depending on the liquid waste disposal option. As

Table 3.1-2: Radium Settling Pond Sludge Accumulation Rates and Retention Times

Radium Settling Pond Parameter	Disposal Option	Value
Pond Sludge Accumulation Rate	Unspecified	See note
	DDW	795 ft^3/yr
	Land App.	1,780 ft^3/yr
Single Pond Retention Time	DDW	12.7 d @ 282 gpm
	Land App.	14.1 d @ 632 gpm
Pond Life/ Project Life	DDW	Pond life is greater than 10 years as described below.
	Land App.	

Note: Unspecified waste disposal option is not currently being evaluated for the Dewey-Burdock Project.

Table 3.1-3: Estimated Sludge Accumulation and Effect on Pond Retention Times for Typical Production Bleed of 0.875%

Radium Settling Pond Parameters	Units*	Liquid Waste Disposal Option	
		DDW	LA
Production Bleed	Mgal	127	127
Restoration Wastewater	Mgal	162	539
CPP Wastewater	Mgal	43	43
Total Project Wastewater	Mgal	332	709
Volume of Sludge @ Project End	ac-ft	0.04	0.09
Volume of Sludge @ 10 Years	ac-ft	0.13	0.35
Volume of Sludge @ 20 Years	ac-ft	0.25	0.71
Operating Capacity of 1 Radium Settling Pond	ac-ft	15.9	39.4
Retention Time, Initial	d	18.3	16.3
Retention Time, Project End	d	18.2	16.3
Retention Time @ 10 Years	d	18.1	16.2
Retention Time @ 20 Years	d	18.0	16.0

* Mgal = million gallons
DDW = deep disposal well
LA = land application
ac-ft = acre-feet
d = days

stated in the Pond Design Report (Appendix 3.1-A), “a literature survey of radium settling ponds has indicated that typical retention times range from 8 to 14 days.” Therefore, radium settling ponds at the Dewey-Burdock Project will have adequate retention times even after 20 years of service, which is significantly longer than the anticipated service life of 8.25 years. In addition, the Satellite Facility and CPP will each have a spare pond suitable for use as a settling pond if the primary ponds need to be temporarily removed from service for sludge removal or repair.

Radium settling pond sludge accumulation and retention times were also evaluated for the maximum production bleed of 3%. These values are presented in Table 3.1-4. The volumes of production bleed and CPP and restoration wastewater were calculated as described above for Table 3.1-3. This table shows that even at the maximum production bleed, pond retention times will still be within the acceptable range of 8 to 14 days for typical radium settling ponds.

Table 3.1-4: Estimated Sludge Accumulation and Effect on Pond Retention Times for a Maximum Production Bleed of 3%

Radium Settling Pond Parameters	Units*	Liquid Waste Disposal Option	
		DDW	LA
Production Bleed	Mgal	436	436
Restoration Wastewater	Mgal	162	539
CPP Wastewater	Mgal	43	43
Total Project Wastewater	Mgal	641	1018
Volume of Sludge @ Project End	ac-ft	0.08	0.13
Volume of Sludge @ 10 Years	ac-ft	0.18	0.41
Volume of Sludge @ 20 Years	ac-ft	0.36	0.82
Operating Capacity of 1 Radium Settling Pond	ac-ft	15.9	39.4
Retention Time, Initial	d	12.8	14.1
Retention Time, Project End	d	12.7	14.1
Retention Time @ 10 Years	d	12.6	14.0
Retention Time @ 20 Years	d	12.5	13.8

* Mgal = million gallons
DDW = deep disposal well
LA = land application
ac-ft = acre-feet
d = days

Central Plant Pond

The purpose of the Central Plant Pond is to temporarily store liquid waste originating from the CPP during uranium recovery and aquifer restoration operations until the CPP liquid waste can be blended with other sources of liquid waste and treated to meet discharge standards.

The CPP liquid waste stream will consist of process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), and may also contain laboratory wastewater, laundry water, plant washdown water, plant sump water, and other minor sources of liquid waste excluding domestic sewage. The CPP liquid waste will be blended with well field production bleed and aquifer restoration bleed prior to final treatment to applicable standards for removal of uranium and other radionuclides.

The Central Plant Pond has been designed to accommodate the CPP liquid waste design flow plus direct precipitation from the 100-year storm event, while maintaining 3 feet of freeboard. As shown in Table 3.1-5, the Central Plant Pond capacity will depend on the liquid waste disposal option. The active waste storage capacity, excluding freeboard and reserve capacity for precipitation, will be 15.2 ac-ft for the DDW option, which is sufficient storage for approximately 287 days at the typical CPP liquid waste production rate of 12 gpm. The Central Plant Pond active waste storage capacity for the land application disposal option will be 35.0 ac-ft. This capacity will allow storage of up to 660 days of CPP liquid waste production at 12 gpm. The Central Plant Pond capacity allows for adequate storage for CPP liquid waste during the initial project startup period when uranium recovery is occurring, but before aquifer restoration activities have started. During this time, CPP liquid waste will need to be stored for approximately 18 months until groundwater sweep water is available for blending with the CPP liquid waste. In addition, the larger capacity will also provide more flexibility for blending the liquid wastes during normal operation. This will be necessary because the land application disposal option will be more sensitive to higher dissolved solids concentrations in the waste stream. A larger Central Plant Pond will also allow for additional excess storage during the winter months when no land application will occur.

The flow rate of the CPP liquid waste from the Central Plant Pond to the radium settling pond will be adjusted according to the concentration of dissolved solids in the CPP liquid water stream. When well field liquid waste has relatively lower concentrations of dissolved solids, for example when restoration is near completion in a particular well field, the percentage of CPP

Table 3.1-5: Central Plant Pond Size and Capacity

Parameters	Units	Deep Disposal Well Option	Land Application Option
Central Plant Pond Total Capacity	ac-ft	15.9	36.2
100-year Precipitation Volume	ac-ft	0.7	1.2
Central Plant Pond Waste Storage Capacity	ac-ft	15.2	35.0
CPP Liquid Waste Flow Rate	gpm	12	12
Liquid Waste Storage Capacity in Time of Operation[1]	yr	0.79	1.81
	d	287	660

[1] During uranium recovery and concurrent uranium recovery and aquifer restoration. Refer to the water balance presented in Section 4.2.2.4.

liquid waste in the waste disposal stream can be higher, or when well field liquid waste has a relatively higher concentration of dissolved solids (e.g., near the end of uranium recovery in a particular well field), the percentage of CPP liquid waste in the waste disposal stream can be lower. Powertech (USA) may also choose to treat the high TDS wastewater from the CPP prior to discharge to the Central Plant Pond or further treatment and discharge to the radium settling ponds.

3.1.6.1.2 Pond Leak Detection

The designs of all proposed ponds consist of a dual liner system with a leak detection system (refer to Appendix 3.1-A). The primary liner and secondary liner are separated by a geonet which provides a physical separation and allows fluid flow between the two liners. The contour of each secondary liner in each pond is graded at approximately 2 percent towards a leak detection sump. Any leakage from the primary liner will be contained by the secondary liner and collected in the leak detection sump. The sump is routinely monitored for the presence of fluid as described below. This leak detection sump is monitored through a pipe installed within the impoundment wall. This pipe allows a submersible pump to be installed within the sump for the purpose of monitoring and/or removal of fluid should a leak occur.

Detection within the leak detection sump will initiate measures to take the pond out of use, remove its contents to another pond, and initiate an investigation into the cause of, and ultimately the repair of the condition creating the leak. The ponds are designed to be completely emptied with the use of a submersible pump.

Pond Inspection

An inspection program based on RG 3.11 will be implemented for all ponds. A detailed checklist will be developed and followed to document the observations of each significant geotechnical, structural, and hydraulic feature, including control equipment. Inspections will be conducted by trained personnel who are knowledgeable of the pond construction and safety features. Inspections will be documented and the reports retained on site for reference and inspection by regulatory authorities. Inspections will include but are not limited to the following:

- Daily inspections of the liner, liner slopes, and other earthwork features
- Daily inspections of pond freeboard
- Monthly inspection of the functionality of leak detection systems
- Daily checks for water accumulation in leak detection systems
- Quarterly inspections of embankment settlement and slope stability. Unscheduled inspections will be performed after occurrence of significant earthquakes, tornadoes, intense local rainfall, or other unusual events

If these inspections reveal any damage or defects that could result in leakage, this information will be reported to the NRC within 24 hours, and appropriate repairs will be implemented as soon as possible.

If significant water is found in the leak detection system, the water in the standpipes will be sampled immediately for indicator parameters to confirm that the water in the detection system is from the pond. The indicator parameters which are proposed to be used are chloride and conductivity. If the analysis confirms a leak, a secondary sample shall be collected and analyzed within 24 hours. Upon confirmation of a leak by the second analysis, the pond will be taken out of service until repairs can be completed. The leak will be reported to the NRC within 24 hours of the confirmation. A pond removed from service because of a confirmed leak will be dewatered by transferring the contents to a spare pond. Regardless of the disposal option used at the project, the Dewey and Burdock areas will each have a spare pond of identical capacity, construction, and dimensions as the primary radium settling ponds. At the Burdock area, the spare pond may also serve as a spare for the Central Plant Pond. A spare storage pond will also be included at each area in the land application disposal option.

3.1.6.1.3 Pond Quality Control Program

Detailed construction specifications, testing, and QA/QC procedures for the ponds are provided in Appendix 3.1-B. The following is a summary of the construction specifications and testing and inspection program for pond construction. In the following specifications "engineer" refers to a professional engineer licensed in South Dakota.

Construction specifications include the following:

i) Clearing, grubbing and stripping: The natural ground surface shall be cleared and stripped and/or grubbed of all organic and objectionable materials. The limits of stripping shall generally be 10.0 feet outside of the work activity areas.

ii) Excavation and fill placement: Excavation shall be to the lines and grades shown on the pond drawings. Excavations shall not exceed a vertical tolerance of plus or minus 0.1 foot, and a horizontal tolerance of 0.5 foot. Fill and backfill shall be placed within a vertical tolerance of plus or minus 0.1 foot, and a horizontal tolerance of 0.5 foot, unless otherwise approved by the Engineer. All precautions necessary to preserve, in an undisturbed condition, all areas outside the lines and grades shown on the drawings, will be taken. Fill will be constructed in near horizontal layers with each layer being completed over the full length and breadth of the zone before placement of subsequent layers. Each zone will be constructed with materials meeting the specified requirements, and shall be free from lenses, pockets and layers of materials, which are substantially different in gradation from the surrounding material in the same zone. All over-sized material shall be removed from the fill material either prior to being placed, or after it is dumped and spread but prior to compaction. The Engineer will conduct testing, as discussed below, to establish suitability of all fill materials used. No fill material shall be placed until the Engineer has inspected and approved the foundation or in-place lift.

iii) Rolling: Compaction of each layer of fill shall proceed in a systematic, orderly and continuous manner that has been approved by the Engineer, to ensure that each layer receives the compaction specified. Compaction equipment shall be routed parallel to the embankment axis or the long axis of the fill zone, and overlap between roll patterns shall be a minimum of 12 inches. The rolling pattern for compaction of all zone boundaries or construction joints shall be such that the full number of passes required in one of the adjacent zones, or on one side of the construction joint, extends completely across the boundary or joint. Compaction equipment shall be of the types and sizes specified in Section 4.6 of Appendix 3.1-B.

iv) Compaction and moisture control: All material, after placing, spreading and leveling to the appropriate layer thickness shall be uniformly compacted in accordance with the requirements for each type of fill as indicated in the following table:

Table 3.1-6: Compaction Requirements

Material	**Compaction Specifications**	**Moisture Content**
Prepared Subgrade	92% of Maximum Dry Density by ASTM D1557	+/- 3% of Optimum
Random Fill	92% of Maximum Dry Density by ASTM D1557	+/- 3% of Optimum
Soil Liner	92% of Maximum Dry Density by ASTM D1557	0 to +5% of Optimum

v) Finishing: Finished grades shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.

Subgrade sterilization and liner sub-drainage and gas venting do not apply to the pond designs presented in Appendix 3.1-B.

<u>Testing and Inspection Program</u>

Inspection of earthwork will involve testing and visual examination of all materials being used for construction to establish compliance with the material requirements, moisture conditioning, spreading procedures, layer thicknesses, and compaction requirements. To ensure that satisfactory quality control is maintained and that the design objectives are achieved, specific testing requirements will be implemented for all materials placed within the Work area. Tests to be carried out will be divided into two categories; control tests and record tests. Control tests will be used to verify whether the materials comply with the specifications prior to placement. Record tests will be used during placement and after completion of the work to assess whether the work and materials meet the requirements of the specifications.

Control tests will include: i) particle size distribution for fill materials, soil liner, filter sand and riprap; ii) moisture content of fill materials and the soil liner; iii) Modified Proctor compaction tests (ASTM D1557) of fill materials and the soil liner: iv) Atterberg limits of fill materials and

soil liner; v) and other tests of fill materials taken from borrow areas and on the fill, as necessary to assess whether the fill material is in compliance with the technical specifications.

The record tests will include: i) particle size distribution for fill materials, soil liner and filter sand; ii) field density test on fill materials and the soil liner; iii) moisture content of the fill materials and soil liner; iv) laboratory compaction and particle size distribution of materials recovered from select field density test locations; v) in-situ laboratory permeability tests on fill materials and the soil liner; vi) Atterberg limit tests on fill materials and the soil liner; vii) other tests on fill compacted in place as necessary to assess whether the compacted fill is in full compliance with the technical specifications.

Testing Frequencies

Geotechnical tests will be conducted to establish compliance of the work with the technical specifications. Standard procedures will be used for all tests. The following tables from Appendix 3.1-B show the test methods and frequency of testing for various materials.

Table 3.1-7: Test Methods

Test Designation[(1),(2)]	Type of Test	Test Methods (ASTM)
C1, R1	Atterberg Limits	D4318
R2a C2, R2b	Nuclear Method Moisture Content Laboratory Moisture Content	D6938 D2216
C3, R3	Particle Size Distribution	D422[(3)]
C4, R4	Laboratory Compaction	D1557
R5a R5b R5c	Nuclear Method Field Density Sand Cone Field Density Water Replacement Field Density	D6938 D1556 D5030
C6, R6	Laboratory Permeability Test	D5084
C7, R7	Riprap Particle Size Distribution	Pebble Count

Notes:

1. C- Denotes Control Tests
2. R- Denotes Record Tests
3. Hydrometer tests down to the 2-micron size will be carried out as directed by the Engineer but will generally not be required. All samples are to be wash graded over a #200 sieve.

Table 3.1-8: Test Frequency- Prepared Subgrade

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	2,000 yd^2
C2, R2a, R2b	Moisture Content	1,000 yd^2
C3, R3	Particle Size Distribution	2,000 yd^2
C4, R4	Laboratory Compaction	2,000 yd^2
R5a	Nuclear Density	1,000 yd^2
R5b	Sand Cone Density	5,000 yd^2

Table 3.1-9: Test Frequency- Random Fill

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	5,000 yd^3
C2, R2a, R2b	Moisture Content	2,500 yd^3
C3, R3	Particle Size Distribution	5,000 yd^3
C4, R4	Laboratory Compaction (Modified Proctor)	5,000 yd^3
R5a	Nuclear Density	1,000 yd^3
R5b	Sand Cone Density	10,000 yd^3
C6, R6	Laboratory Permeability Test	5,000 yd^3

Table 3.1-10: Test Frequency - Soil Liner

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	1,000 yd^3
C2, R2a, R2b	Moisture Content	500 yd^3
C3, R3	Particle Size Distribution	1,000 yd^3
C4a, R4a	Laboratory Compaction	1,000 yd^3
R5a	Nuclear Density	1,000 yd^3
R5b	Sand Cone Density	2,500 yd^3
C6, R6	Laboratory Permeability Test	1,000 yd^3

Table 3.1-11: Test Frequency - Filter Sand

Test Designation	Type of Test	Frequency (1 per)
C3, R3	Particle Size Distribution	250 yd^3

Table 3.1-12: Test Frequency - Riprap

Test Designation	Type of Test	Frequency (1 per)
C7, R7	Riprap Particle Size Distribution	1,000 yd^3

3.1.6.2 Land Application System Design

Two general land application areas are proposed for liquid waste disposal within the project area, one near the Dewey satellite facility and one near the Burdock CPP. Each land application area will have 315 acres of irrigated area along with 65 acres of auxiliary area on standby. The required land application area was estimated from the disposal capacity obtained using the SPAW (Soil-Plant-Atmosphere-Water) model, which was developed by the USDA to simulate the daily hydrologic budget for agricultural landscapes. The inputs to the model include climatic data, soil profile information, and crop growth information. Additional information on the SPAW model, as well as the model inputs and outputs, is included in the Pond Design Report (Appendix 3.1-A).

In the land application option, pumping will occur 24 hours a day. The estimated daily water budgets obtained from SPAW modeling indicate that each land application area will be capable of disposing approximately 297 gpm from March 29 to May 10, about 653 gpm from May 11 to September 24, and approximately 297 gpm from September 25 to October 31. Normally there will not be land application disposal from approximately October 31 to March 29. Detailed information regarding the SPAW model inputs and outputs are discussed in Appendix D to the Pond Design report, which is provided as Appendix 3.1-A. The land application system will be capable of handling all of the expected liquid waste throughout each phase of the project. During the winter months liquid waste will be stored in ponds, which are described in more detail in

Sections 3.1.6.1 and 4.2.2. The capacity required to store the liquid waste throughout the winter months was calculated using the SPAW model to be approximately 216 acre-feet. By comparison, the total storage pond capacity under the land application option will be approximately 510 acre-feet, not including spare storage ponds. Figure 3.1-1 depicts the proposed facilities in the land application option.

3.1.6.2.1 Relationship between Land Application and Potential Well Field Areas

The locations of the proposed land application areas in relation to potential well field areas are depicted on Figures 3.1-13 and 3.1-14. Figure 3.1-13 shows minimal overlap between Dewey land application areas and potential well field areas. The only land application areas that potentially will overlap with well fields are designated for standby operation. These standby areas will serve as contingency areas and generally will not be used at the same time as the underlying well fields.

Figure 3.1-14 shows that there is also limited potential overlap between Burdock land application areas and potential well field areas. In this case overlap will likely be limited to perimeter monitor wells.

Although overlap between active land application areas and potential well field areas will be limited, there may be times that production, injection and monitor wells are operated within active land application areas. Powertech (USA) will design and construct the well fields and land application systems to avoid any potential conflicts and minimize potential risks. The irrigation nozzles will be suspended above the well head covers, and wells and fences will be positioned to avoid the center pivot wheel pathways. Injection, production and monitor wells will have sealed well heads to prevent entry of the land application water. The well heads will also have sufficient aboveground casing to ensure that surface water cannot enter the wells. Injection and production pipelines will be buried and will not conflict with land application systems. Perimeter monitor wells will have pressure transducers that will allow remote monitoring of water levels. If necessary, discharge piping and pressure transducer cable will be installed from the monitor wells to remote sampling locations outside of the land application area. This would allow Powertech (USA) personnel to measure water levels and sample monitor wells without traveling through active land application areas. Inspections of well field components will be conducted routinely as discussed in Sections 3.1.5 and 3.2.12.

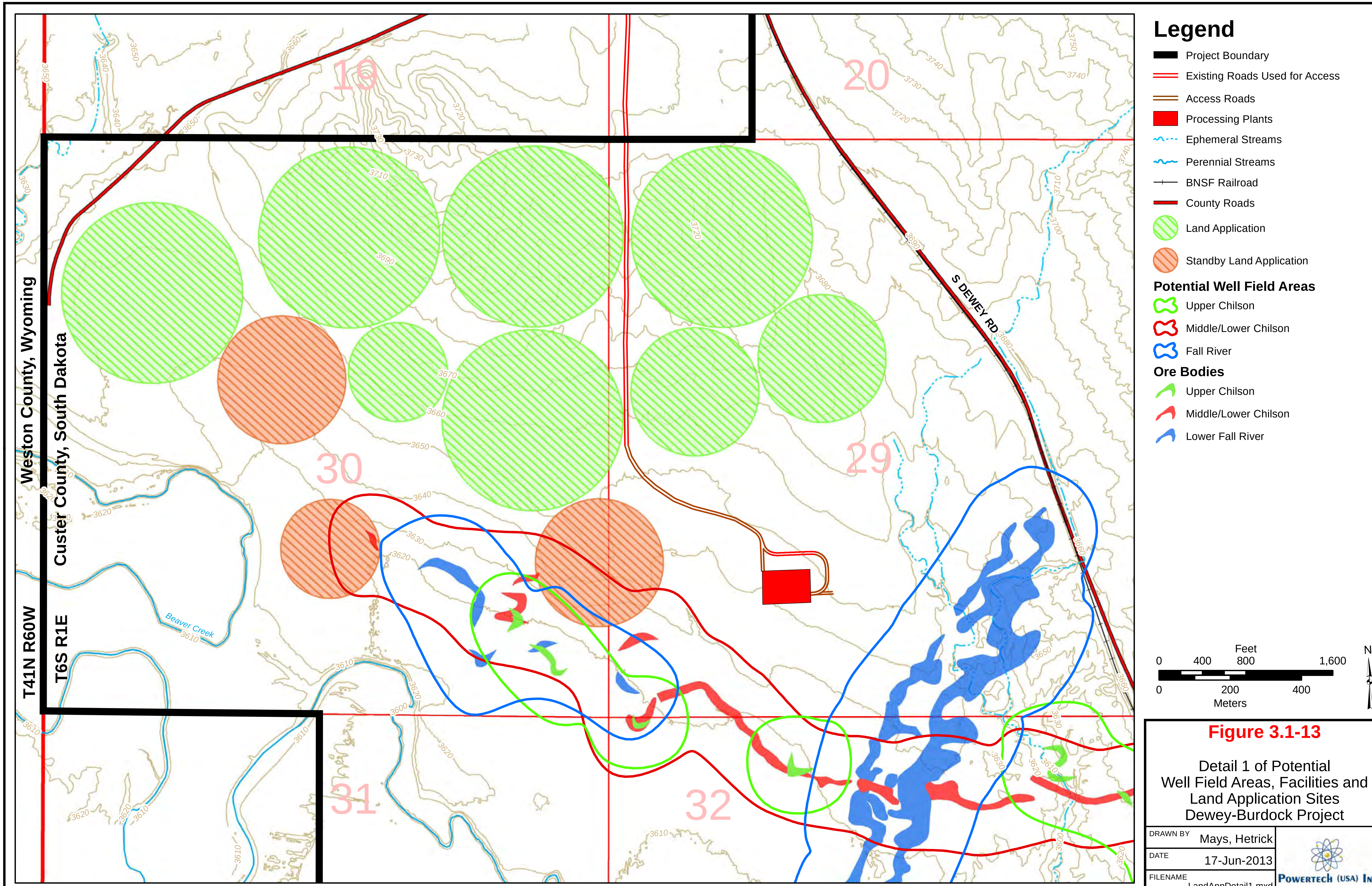


Figure 3.1-13

Detail 1 of Potential Well Field Areas, Facilities and Land Application Sites Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	17-Jun-2013
FILENAME	LandAppDetail1.mxd

Powertech (USA) Inc.

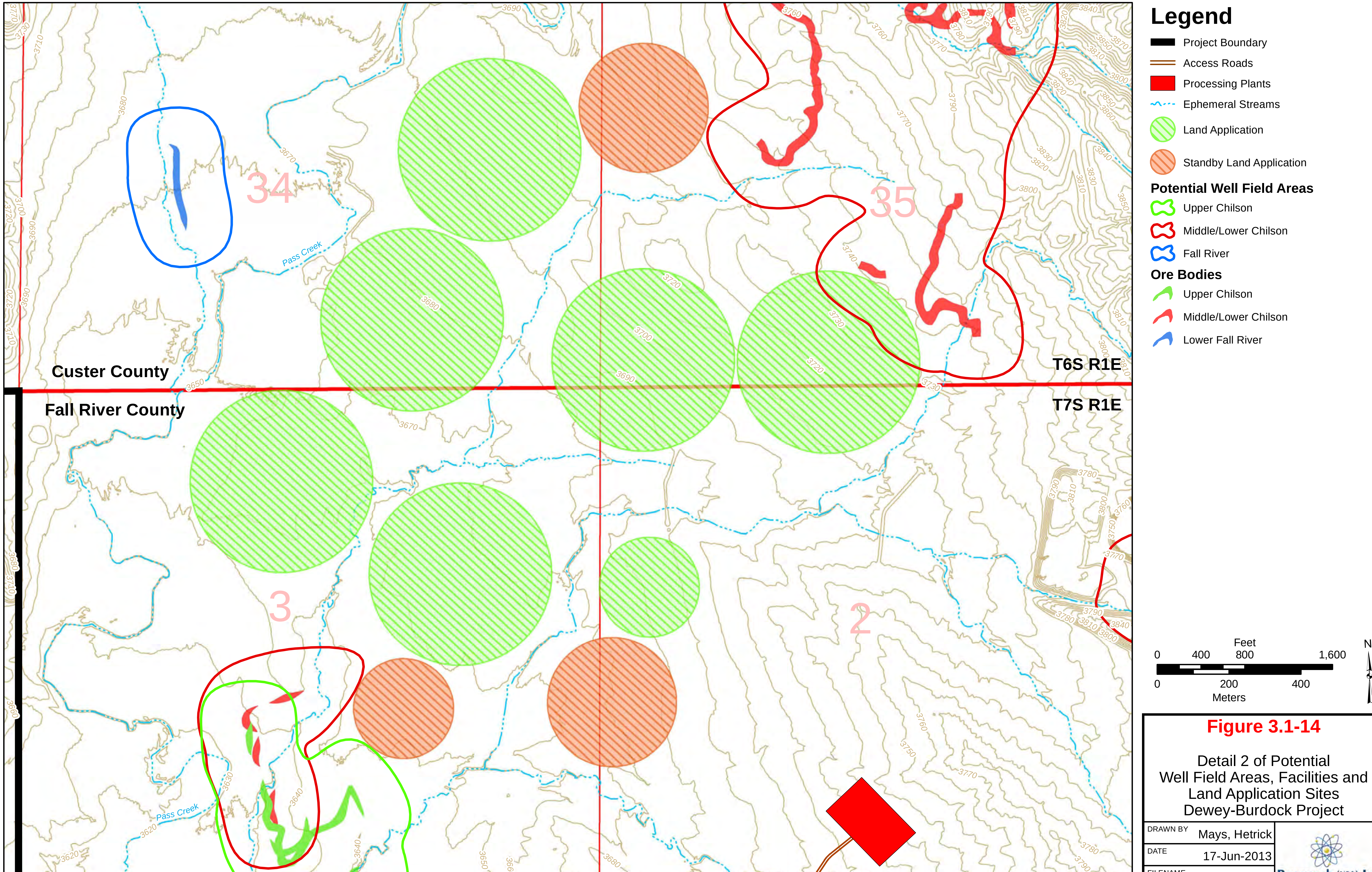


Figure 3.1-14

Detail 2 of Potential Well Field Areas, Facilities and Land Application Sites Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	17-Jun-2013
FILENAME	LandAppDetail2.mxd

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3.1.6.3 Deep Disposal Well Design

The Class V UIC Permit Application for disposal of non-hazardous liquid wastes was submitted by Powertech (USA) to EPA in March 2010. The application is included as Appendix 2.7-L. Through its submittal of a UIC permit application for Class V non-hazardous injection wells, Powertech (USA) requested an Area Permit and authorization from EPA to install and operate four to eight non-hazardous Class V disposal wells at the Dewey-Burdock Project in Fall River and Custer Counties, South Dakota.

Injected fluids will be delivered to the Minnelusa and Deadwood Formations in separate wells under positive pressure injection through tubing and a packer. Fresh water aquifers will be protected by casing and cement. The wells will have one cemented long string protective casing extending into the injection interval and the wellbores will be perforated over the injection interval. The annulus area between the protective casing and injection tubing strings will be filled with inhibited fresh water. Annulus pressure will be continuously monitored to detect potential leaks in the tubing and casing strings. An analysis of potential target disposal zones is included in the Class V application and is summarized below.

Synopsis of Analyses to Determine Target Disposal Zone(s)

The Class V application is for an Area Permit and authorization to install and operate four to eight Class V non-hazardous disposal wells for underground injection of fluids from Powertech (USA)'s proposed Dewey-Burdock uranium ISR project.

Within the Black Hills area, both groundwater quality and use are highly variable and dependent on location. Regionally, the major bedrock aquifers in the Black Hills area include the Deadwood Formation, Madison Limestone, Minnelusa, Minnekahta, and Inyan Kara Group. These aquifers are regionally extensive in areas surrounding the Black Hills. Based on TDS concentrations, only the Madison and Inyan Kara are considered to be Underground Sources of Drinking Water (USDWs) in the Dewey-Burdock area. The Deadwood, Minnelusa, and Minnekahta are not used as a water supply and are not USDWs in the Dewey-Burdock area. As summarized below, the Deadwood and Minnelusa appear to have suitably high TDS and porosity to be considered as injection zones for deep disposal wells.

Minor aquifers include the Sundance Formation and Unkpapa sandstone which may be USDWs in the Dewey-Burdock area.

Deadwood Formation - The Cambrian Deadwood Formation consists of massive to thinly-bedded, brown to light-gray sandstone, greenish glauconitic shale, dolomite, and flat-pebble limestone conglomerate and ranges from 0 to 500 feet thick. Because of its depth and stratigraphic position immediately overlying the Precambrian basement, the Deadwood is not a USDW in the project area. There are no known water wells completed in the Deadwood in the project area. Although water-quality data are not available for the Deadwood Formation locally, it is likely that TDS concentrations are in excess of 10,000 mg/L.

Madison Formation - The Mississippian Madison aquifer is contained within the limestones, siltstones, sandstones and dolomites of the Madison Limestone Group. Generally, water in the Madison is confined except in outcrop areas and frequently exists under artesian pressure. Water in the Madison is typically fresh only near the recharge areas, becoming slightly saline to saline as it moves down-gradient. In the deeper parts of the Williston Basin, the water is a brine with TDS concentrations larger than 300,000 mg/L. Locally, the Madison is used as a water supply for the City of Edgemont, approximately 12 miles southeast of the project area.

Minnelusa Formation - The Pennsylvanian/Permian Minnelusa Formation consists of yellow to red, cross-stratified sandstone, limestone, dolomite, and shale. The Minnelusa aquifer occurs primarily in the sandstone and anhydrite beds in the upper part of the formation. The Minnelusa is confined above by the Opeche Shale and below by layers of lower permeability within the Minnelusa.

The Minnelusa is an oil and gas producer in the vicinity of the project area. TDS concentrations locally are in excess of 10,000 mg/L. The Minnelusa is not used locally as a source of water supply. As such, the Minnelusa is not considered to be a USDW in the project area.

Minnekahta Formation - The Permian Minnekahta Limestone is a thin to medium-bedded, fine-grained, purple to gray, laminated limestone, which ranges in thickness from 25 to 65 feet. The Minnekahta is considered a major aquifer in parts of the Black Hills area but does not supply any known water wells in the project area.

Sundance - The Sundance Formation consists of greenish-gray shale with thin limestone lenses, glauconitic sandstone, with red sandstone near the middle of the formation. The Sundance ranges from 250 to 450 feet thick.

Unkpapa - The Unkpapa Sandstone is a massive fine-grained sandstone, 0 to 225 feet thick.

Inyan Kara Group - The Inyan Kara Group includes the Lakota and Fall River Formations; the Lakota Formation is divided into the Chilson, Minnewaste, and Fuson Members. The Inyan Kara is confined by thick shales of the Graneros Group except in outcrop areas around the Black Hills Uplift. Although the Inyan Kara aquifer is widespread, it contains little fresh water except in small areas in central and south-central Montana and north and east of the Black Hills Uplift. In the project area, the Inyan Kara is used as a source of water supply.

Basis for Number of Wells

During development of the Class V UIC Permit Application, it was estimated that four to eight deep disposal wells will be necessary to handle the volume of liquid wastes for disposal from the Dewey-Burdock Project. The number of wells that may be required will be determined following drilling of a test well and is dependent upon well capacity. Redundancy with regard to deep well disposal of liquid waste is provided by multiple wells interconnected via pipeline to the plant. Because of this redundancy, shut down of a single disposal well would not adversely impact production operations or restoration.

The use of surface impoundments provides an additional layer of redundancy for disposal of liquid wastes during ISR operations. Pond capacity is described in Section 3.1.6.1.

Status of Application for Class V UIC Permit

The Class V Application was submitted to EPA on March 20, 2010 and deemed complete on April 28, 2010. EPA's review of the Application is in progress.

Compliance with Requirements of 10 CFR § 20.2002

For information on the anticipated treated liquid waste water quality and the anticipated effluent limits for Class V deep disposal wells, refer to Section 3.1.6.4. Because liquid waste will be treated to the 10 CFR 20, Appendix B, Table 2, Column 2 standards, it will not be classified as radioactive waste.

3.1.6.4 Liquid Waste Quality and Treatment

The anticipated liquid waste quality at the Dewey-Burdock Project is presented in Table 3.1-13. A discussion of the anticipated liquid waste quality in relation to Class V DDW regulations and land application requirements is presented below.

Table 3.1-13 shows the estimated water quality of various liquid waste streams for the Highland ISR Facility. The water quality of liquid waste from the Dewey-Burdock Project is expected to fall within the broad ranges of concentrations shown in the table because both the Dewey-Burdock Project and Highland ISR Facility will use virtually identical processes and chemistry during ISR operations. The column labeled "Restoration Wastes" is expected to be representative of the quality of the production bleed and the restoration composite streams at the Dewey-Burdock Project prior to treatment. In the land application disposal option, the final liquid waste disposal stream is expected to have similar water quality to the range shown under "Restoration Wastes" in Table 3.1-13, except that radium-226 and gross alpha will be reduced by treatment in

the radium settling ponds. For the DDW liquid waste disposal option, the restoration composite will be treated with RO and the resulting brine will be combined with other liquid waste (e.g., production bleed, process solutions, etc.) in the lined ponds prior to disposal in the DDWs. In the DDW liquid waste disposal option, the water quality of the composite liquid waste stream will more closely resemble the first four columns in Table 3.1-13 depending on the specific contribution from each of the liquid waste sources. The anticipated land application liquid waste water quality is shown in Table 4.2-7.

EPA issued a final rulemaking in December 1999 that revised the Class V Underground Injection Control (UIC) regulations. The revisions reclassified all wells which dispose of radioactive waste as Class I wells (40 CFR 144.6(a) and 146.5(a)). Since South Dakota law prohibits Class I DDWs, the liquid waste stream will be treated to remove radioactive constituents. It will then be disposed in Class V DDWs or a land application system. In order to meet the Class V UIC or land application requirements, Powertech (USA) will treat the liquid waste to reduce radionuclide activities below the established limits for discharge of radionuclides to the environment, which are listed in 10 CFR Part 20, Appendix B, Table 2, Column 2. These limits are presented in Table 3.1-14. These limits are based on Annual Limits on Intake (ALI) of radionuclides for occupational exposure. Waste streams containing radionuclides below these regulatory limits are not classified as radioactive waste as per 10 CFR 20.2002.

Liquid wastes will be treated to achieve uranium effluent limits in the IX columns. It is not anticipated that thorium-230 and lead-210 will be present at concentrations above the limits; however, if concentrations are above the limits, the effluent will be treated as necessary to satisfy the Appendix B limits. Radium-226 will be treated in radium settling ponds by adding barium chloride to the liquid waste to co-precipitate radium-226 with barium sulfate. Additional information about the radium settling pond design can be found in the Pond Design Report (Appendix 3.1-A). The technology for radium removal by barium chloride is well developed (e.g., Kirby and Salutsky, 1964).

Table 3.1-13: Estimated Liquid Waste Water Quality

Estimated Flow Rates and Constituents in Liquid Waste Streams for the Highland In-Situ Leach Facility*					
	Water Softener Brine	**Resin Rinse**	**Elution Bleed**	**Yellowcake Wash Water**	**Restoration Wastes**
Flow Rate, gal/min	1	<3	3	7	450
As, ppm					0.1–0.3
Ca, ppm	3,000–5,000				
Cl, ppm	15,000–20,000	10,000–15,000	12,000–15,000	4,000–6,000	
CO_3, ppm		500–800			300–600
HCO_3, ppm		600–900			400–700
Mg, ppm	1,000–2,000				
Na, ppm	10,000–15,000	6,000–11,000	6,000–8,000	3,000–4,000	380–720
NH_4, ppm			640–180		
Se, ppm					0.05–0.15
Ra-226, pCi/L	<5	100–200	100–300	20–50	50–100
SO_4, ppm					100–200
Th-230, pCi/L	<5	50–100	10–30	10–20	50–150
U, ppm	<1	1–3	5–10	3–5	<1
Gross Alpha, pCi/L					2,000–3,000
Gross Beta, pCi/L					2,500–3,500
*NRC. NUREG–0489, "Final Environmental Statement Related to Operation of Highland Uranium"					

Source: NUREG-1910, Table 2.7-3

Table 3.1-14: Anticipated Effluent Limits for Class V DDWs

Radionuclide	**Anticipated Effluent Limits**	
Units	µCi/ml	pCi/L
Lead-210	1E-8	10
Radium-226	6E-8	60
Uranium-nat.	3E-7	300
Thorium-230	1E-7	100

Source: 10 CFR 20 Appendix B, Table 2, Column 2

3.1.7 Surface Water Management

Powertech (USA) has evaluated flood inundation boundaries and will construct facilities outside of these boundaries to avoid potential impacts to facilities from flooding and potential impacts to Beaver Creek and Pass Creek in the event of any potential spills or leaks.

Estimates of peak flood discharges and water levels produced by floods on Pass Creek, Beaver Creek and local small drainages are provided in Section 2.7.1 and Appendix 2.7-M. Plate 2.7-1 depicts the modeled flood inundation areas for all surface water features during the 100-year, 24-hour storm event in relation to proposed facilities and infrastructure. As described in Appendix 2.7-M, HEC-HMS models were used to calculate peak discharges, and HEC-RAS models were used to compute water-surface profiles and inundated areas for the respective runoff events.

Where possible, facilities will be located out of the 100-yr flood inundation boundary. Facilities which must be located within such boundaries will be protected from flood damage by the use of straw bales, collector ditches, and/or berms. Diversion channel designs for the plant sites and ponds are provided in Appendix 3.1-B. Diversion channels for the CPP facilities are depicted on Drawing No. 101 (pg. 3.1-B-33), and diversion channels for the Satellite Facility are depicted on Drawing No. 102 (pg. 3.1-B-34). As shown on these drawings, control structures (collector ditches and berms) will be used to prevent surface runoff for events up to and including the 100-yr, 24-hr rainfall event from entering the ponds. Collector ditches will be designed to have velocities less than 5 feet per second or appropriate erosion control measures, such as fabric mats or riprap, will be constructed to minimize the potential for erosion. If it is necessary to place a well head within the inundation boundary, diversions or erosion control structures will be constructed to divert flow and protect the well head. The well head also will be sealed to withstand brief periods of submergence. Pipelines will be buried below the frost line and will not be subject to flooding. Pipeline valve stations will be located outside of the 100-year flood inundation boundary.

Surface water/groundwater interactions and potential impacts to these media from site activities are discussed in Section 7 of this application.

3.1.8 Quality Control

Quality Control during construction, operations, and reclamation will be assured through strict compliance with construction plans and specifications, operations manuals, and standard operating procedures. During construction, quality will be assured through material testing programs prescribed in the specifications, review of testing results by the design engineer, and inspection and acceptance of work products by the owner’s representative.

During operations, standard operating procedures developed during project design will be followed. Operations supervisors will instruct field personnel as to the documented procedures and routinely inspect and document their performance.

Refer to Section 3.1.6.1.3 for the pond construction quality control program.

3.1.9 Approved Waste Disposal Agreement for 11e.(2) Material

Powertech (USA) will provide an approved waste disposal agreement for 11e.(2) byproduct material prior to beginning operations. Powertech (USA) understands that without such an agreement operations cannot begin. Powertech (USA), therefore, acknowledges that without an approved 11e.(2) byproduct material disposal agreement in place prior to issuance of a license, NRC will include a license condition requiring verification of an approved 11e.(2) byproduct material disposal agreement at an NRC or NRC Agreement State licensed disposal facility prior to the start of operations.

3.2 Central Processing (CPP) and Chemical Storage Facilities; Equipment Used and Material Processed

One SF will be located at the Dewey site and a combination SF/CPP will be located at the Burdock site (Figures 3.1-1 and 3.1-2). The downstream uranium recovery processes described in the preceding section will be accomplished in several steps. Uranium recovery from the solution by IX, subsequent processing of the loaded IX resin to remove the uranium (elution), the precipitation of uranium, thickening of the uranium slurry, and the dewatering, drying, and packaging of solid uranium oxide (yellowcake) will be performed at the CPP.

The sites for both the CPP and the SF have been designed to provide security and ease of access for operating purposes. The sites are designed with ample areas for access by resin transfer trucks as well as truck transports for chemical delivery and shipment of product and byproduct materials. Figure 3.2-2 shows the site layout of the CPP site, including the placement of an office building, a maintenance shop and the CPP proper. Traffic routes and truck turning radii are indicated on this figure. The site layout for the SF is shown in Figure 3.2-3.

All buildings, structures, foundations, and equipment will be designed in accordance with recommendations in the latest versions of the International Building Code and ASCE-7 published by the American Society of Civil Engineers. Maps published in ASCE-7, and the latest version of the USGS Earthquake Ground Motion Tool, along with information regarding soil characteristics provided by the project professional geotechnical engineer, will be used to determine seismic loadings and design requirements.

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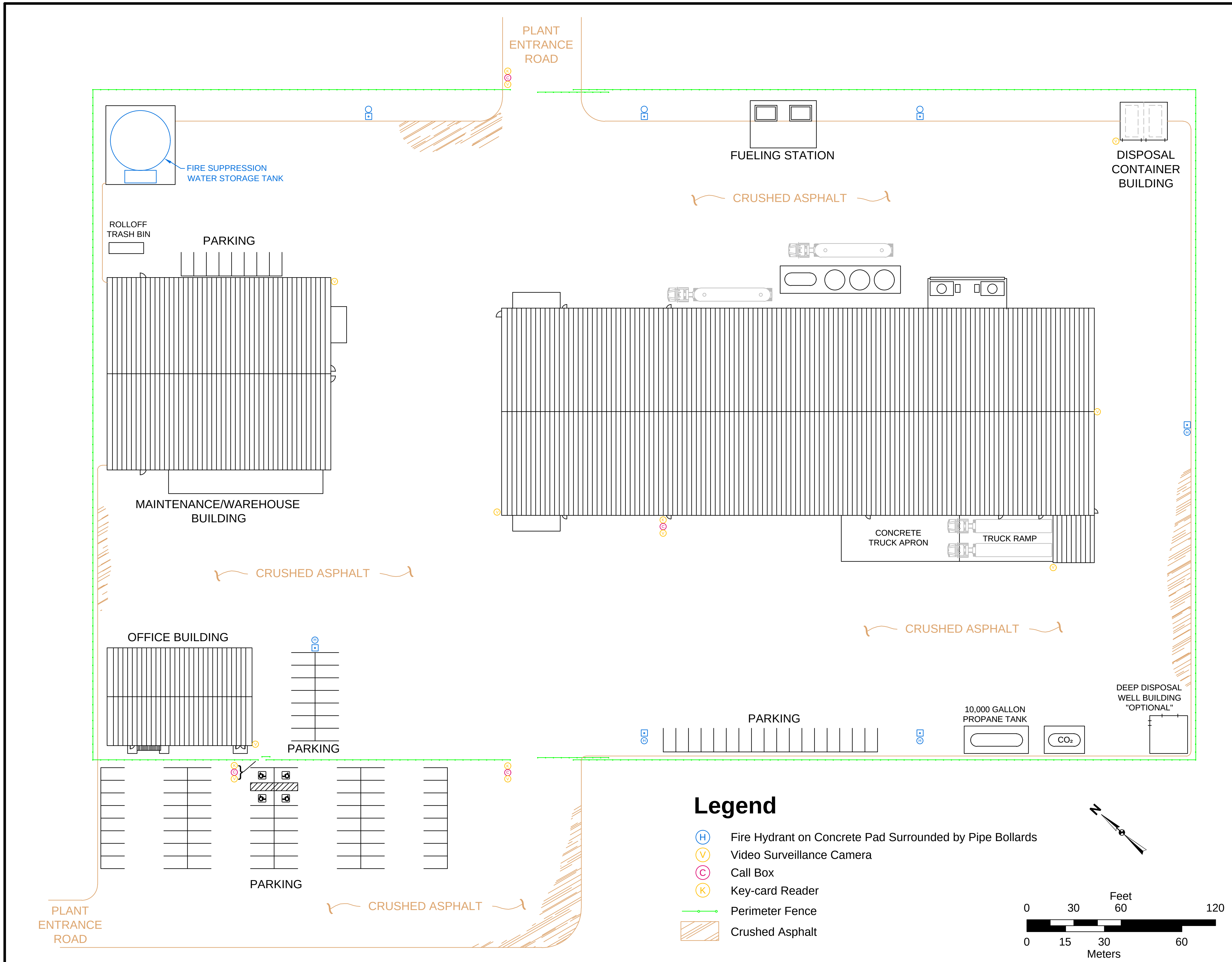


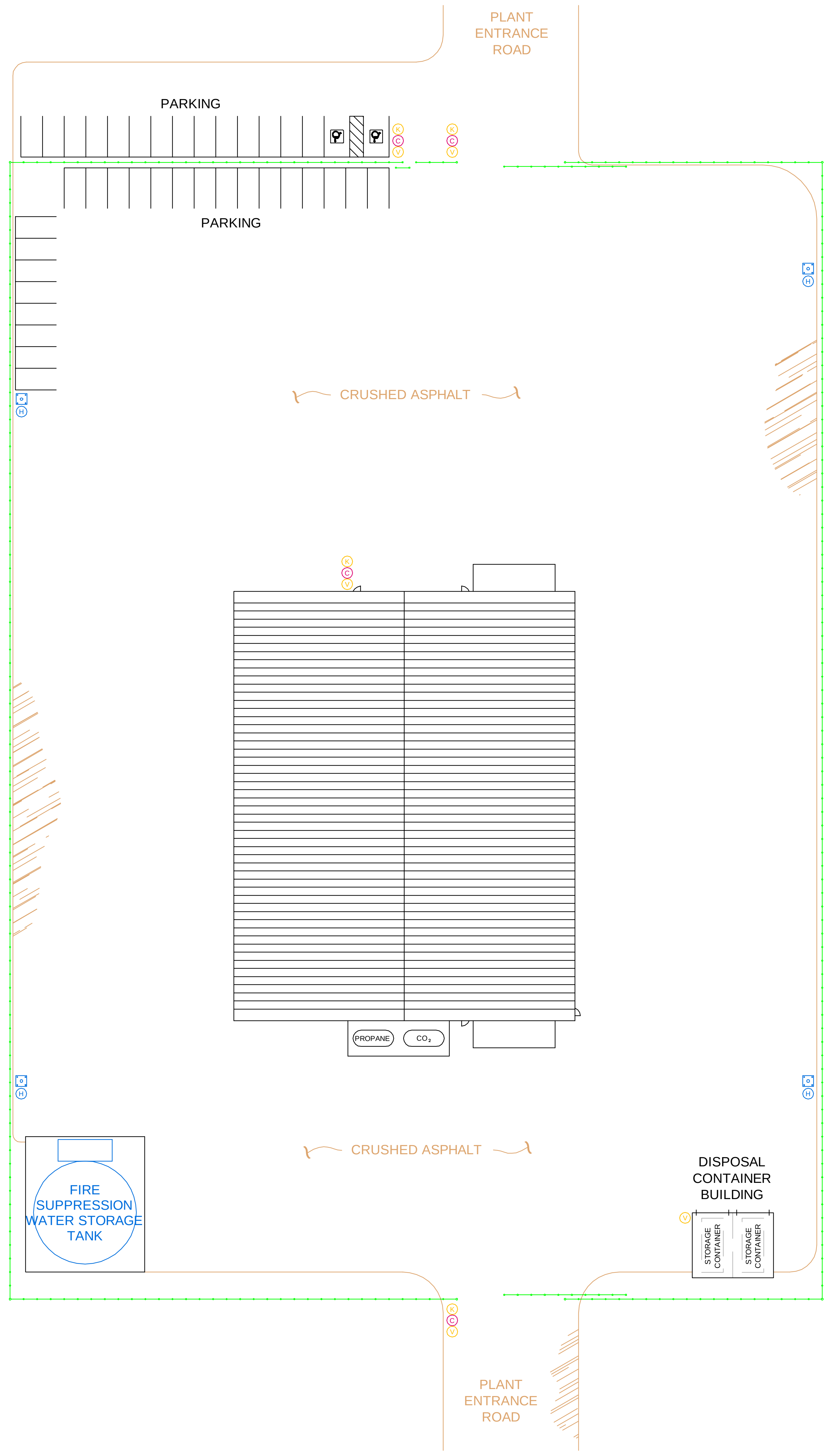
Figure 3.2-2

General Site Plan
Central Processing Plant

Dewey-Burdock Project

DRAWN BY S. Hetrick
DATE 02-Jan-2014
FILENAME CPP-SitePlan-New.dwg

POWERTECH (USA) INC.



Legend

- (H) Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- (V) Video Surveillance Camera
- (C) Call Box
- (K) Key-card Reader
- Perimeter Fence
- Crushed Asphalt

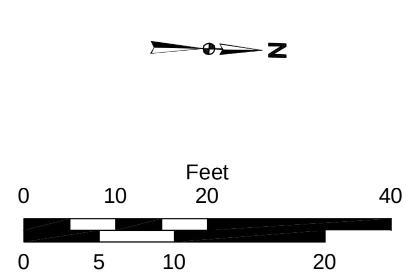


Figure 3.2-3

General Site Plan
Satellite Facility

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	17-Dec-2013
FILENAME	Figure 3.2-3.dwg

POWERTECH (USA) INC.

3.2.1 CPP Equipment

The processing facilities will be housed in pre-engineered metal buildings. The equipment layout within these buildings is shown in Figures 3.2-4 and 3.2-5 for the CPP and SF, respectively. The CPP includes the following:

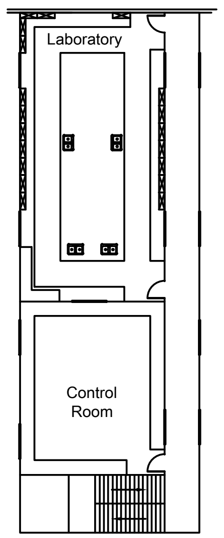
- IX
- Chemical addition
- Filtration
- Elution circuit
- Precipitation and thickening circuit
- Product dewatering, drying and packaging
- Liquid waste stream circuit
- Drum storage and decontamination area
- Waste Storage buildings are located at the SF in Dewey and the CPP area at Burdock.

Based on preliminary design and site geotechnical evaluations, the project CPP will be located within Section 2, T7S, R1E. Chemical storage and a septic tank and leachfield will also be located within this area. The Dewey SF will be located in Section 29, T6S, R1E. These plant locations are shown in Figures 3.1-1 and 3.1-2.

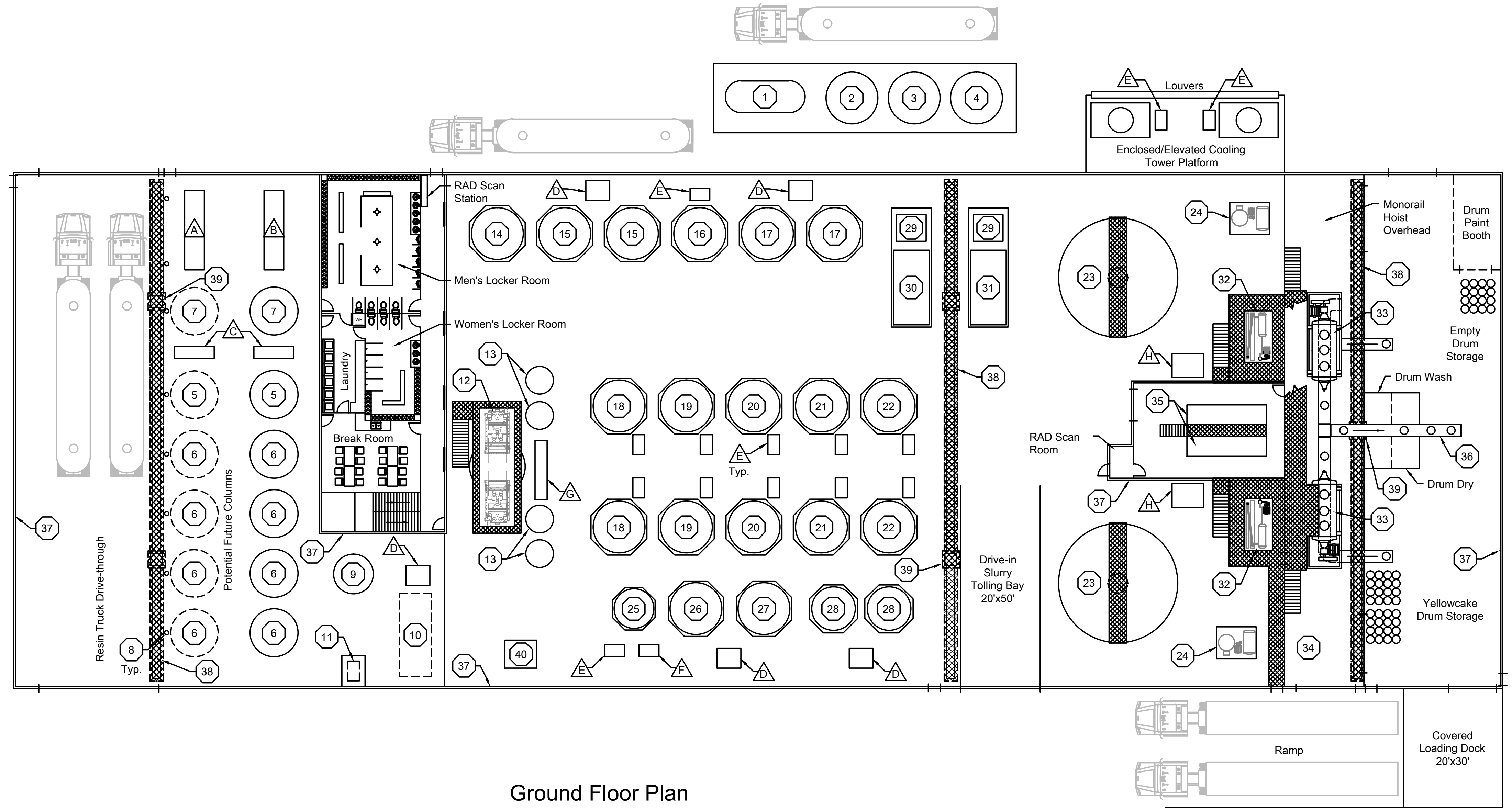
Powertech (USA) proposes to install up to eight underground pipelines between the CPP and the Satellite Facility to transport the various fluids present during ISR operations. Conduits for electronic communication and control purposes may also be installed between the CPP and the Satellite Facility. The fluids that will be transported include, but are not limited to: barren and pregnant lixiviant, restoration water, RO reject brines, wastewater resulting from well drilling and maintenance operations, and supply water from the Madison Formation or other aquifers. All infrastructure associated with the proposed project will be located within the license boundary.

The CPP will serve production from Dewey-Burdock ISL operations, and possibly resin from other potential Powertech (USA) satellite projects in the area. In addition, depending on market conditions and regional demand for yellowcake processing, the CPP may be used for tolling arrangements with other ISL operations licensed under a different operator.

The following subsections present a description of each recovery and processing system and the equipment components comprising each system. An overall process flow diagram is presented in Figure 3.2-6.



Second Floor Plan



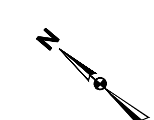
Ground Floor Plan

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'∅
6. Process IX Column 12'∅
7. Bleed IX Column 12'∅
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'∅
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'∅
14. Reclamation Make-up Water 13'∅
15. NaCl 13'∅
16. Na_2CO_3 13'∅
17. Utility Water 13'∅
18. Fresh Eluant 13'∅
19. Lean Eluant 13'∅
20. Intermediate Eluant 13'∅
21. Rich Eluant 13'∅
22. Precipitation 13'∅
23. 30'∅ Thickener, 5'∅ Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'∅
26. High TDS Wastewater Tank 13'∅
27. Low TDS Wastewater Tank 13'∅
28. Solids Removal Tank 11'∅
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A: 5'x20' - PC Booster Pumps
- B: 5'x20' - IC Booster Pumps
- C: 3'x10' - Pump
- D: 6'x5' - Pump
- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump



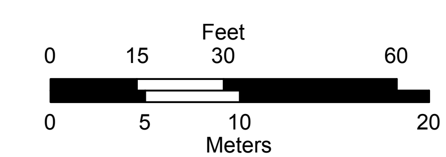


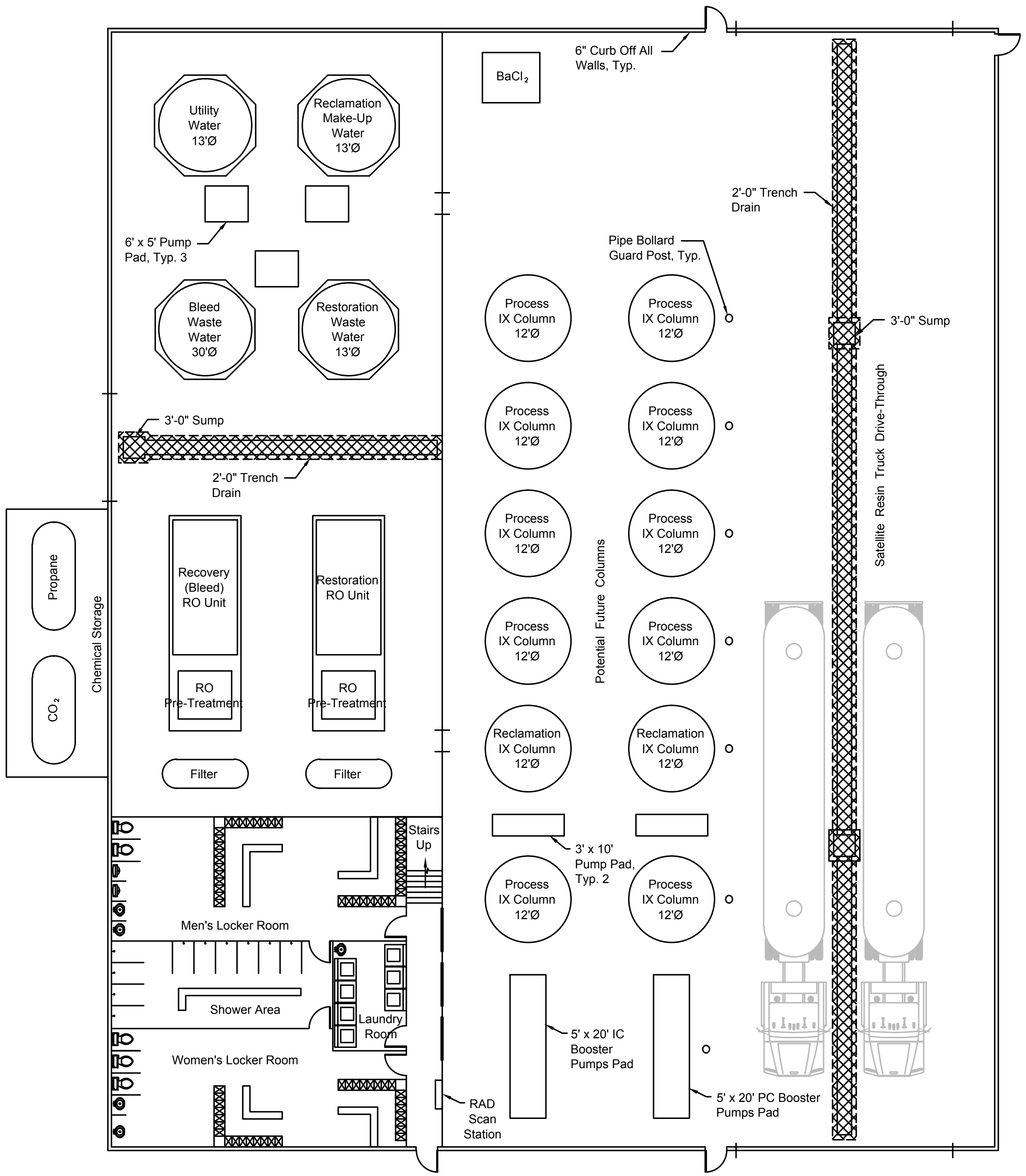
Figure 3.2-4

Central Processing Plant Detail

Dewey-Burdock Project

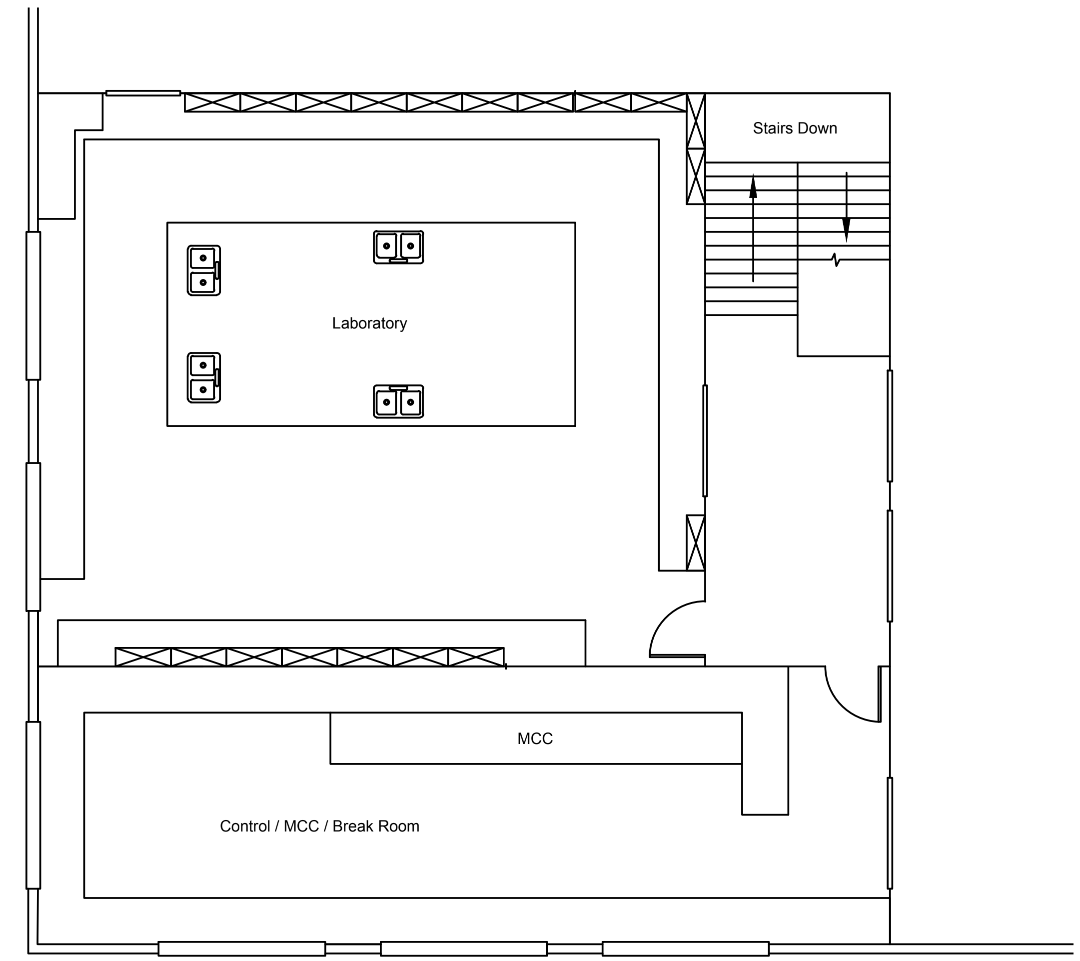
DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	CPP-Floorplan.dwg

Powertech (USA) Inc.



Ground Floor Plan

Feet: 0 10 20 40
Meters: 0 5 10



Second Floor Plan

Feet: 0 5 10 20
Meters: 0 2 4 6

N

Figure 3.2-5

Satellite Facility Plant Detail

Dewey-Burdock Project

DRAWN BY J. Mays
DATE 14-Jun-2013
FILENAME SPP-Floorplan.dwg

POWERTECH (USA) INC.

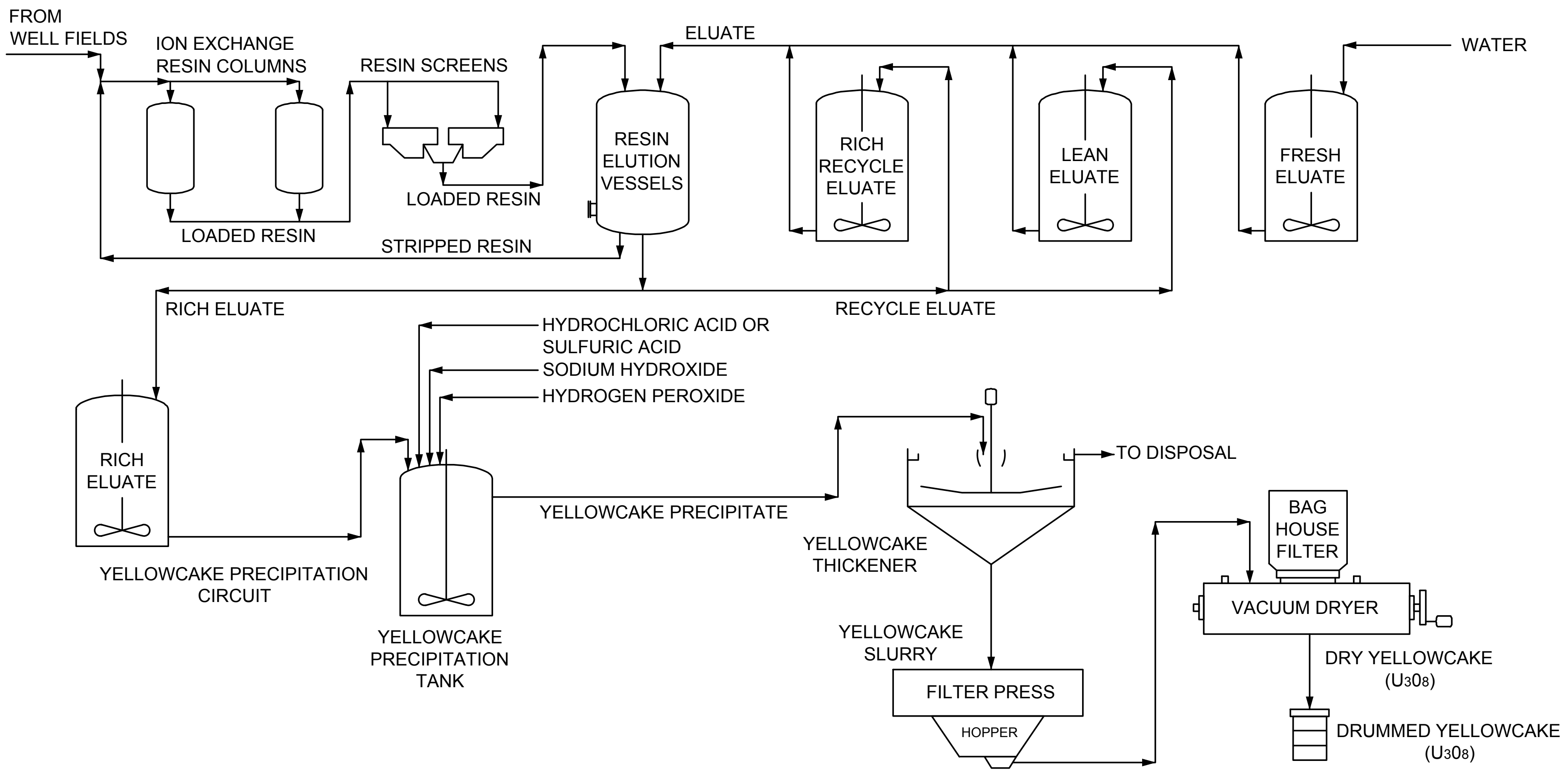


Figure 3.2-6

Process Flow Diagram

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	PFD.dwg

Powertech (USA) Inc.

3.2.2 Recovery

Recovery of the uranium from the uranium bearing or pregnant lixiviant solution will be accomplished via an ion exchange process. The pregnant lixiviant from the well field will be pumped through IX vessels containing uranium-specific IX resin beads (Dowex 21K XLT or equivalent). As the lixiviant flows through the resin beds, the complexed uranium molecules attach themselves to the beads of resin, displacing a chloride ion or bicarbonate ion as shown below:

$$2\ RCl + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + 2Cl^{-1}$$

$$2\ RHCO_3 + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

Each resin bead has a finite number of sites where the uranium complex can attach. When most of the available sites in the resin bed are occupied by uranyl dicarbonate (UDC) or uranyl tricarbonate (UTC) ions, the resin will be considered to be "loaded" and will be ready for processing.

The IX vessels will be designed to operate in downflow mode, and each will contain approximately 500 ft^3 of IX resin. The IX vessels will be arranged in multiples of two vessels in series. The lixiviant will be passed through the primary or lead vessel which will be where most of the resin loading takes place. The lixiviant will then pass through the secondary or lag vessel where the solution will be "polished" by removal of any remaining dissolved uranium. When the lead vessel becomes loaded, it will be taken off line and flow of lixiviant will be routed to the secondary vessel which will become the lead vessel. The resin in the off-line vessel will be removed and regenerated resin will be returned to the vessel. The vessel containing the regenerated resin will be then brought back on line in the lag position. The resin that was removed will be transferred to the elution and regeneration process in the CPP.

After passing through the IX vessels, the barren lixiviant will be returned to the well field where oxygen and carbon dioxide will be added prior to reinjection. A booster pump station may be required to achieve the required injection pressure. A sidestream referred to as the production bleed will be removed from the barren lixiviant and routed to either the wastewater system or the production bleed reverse osmosis (RO) system, depending on which liquid waste disposal option, as discussed in Section 3.1.6, is utilized. The flowrate of this sidestream will be approximately 0.5 percent to 3 percent of the pregnant lixiviant flowrate. The purpose of the production bleed

stream is to maintain a hydraulic gradient towards the well field, as discussed in Section 3.1.

3.2.2.1 Recovery Equipment

The recovery equipment includes the recovery IX vessels, the production bleed reverse osmosis system (deep disposal well option only), and the recovery and injection composite booster pumps.

Ion Exchange Vessels

The IX columns will be vertical cylindrical pressure vessels with dished heads. The vessels will be constructed of fiberglas-reinforced plastic (FRP), and will be approximately 13 feet in diameter with a seam to seam height of 8 feet. The vessels will be constructed according to American Society of Mechanical Engineers (ASME) Section VIII specifications. Each vessel will be equipped with an upper flow distribution plate and a lower flow distribution manifold constructed of stainless steel pipe and slotted well screen. The IX vessels will be designed to provide optimum contact time between pregnant lixiviant and IX resin. These vessels can be operated at a wide range of flowrates without loss of performance.

At the SF and the CPP, the air/vacuum relief valves on the IX columns will be piped together in a manifold which will be vented above the roofline of the building. In addition, a flexible duct designed to attach to tanker trucks during loading and unloading of resin will be connected to this vent manifold. This vent system will not have a fan because vacuum relief requires an inflow of air.

Each vessel will be equipped with a pressure relief valve and an air/vacuum release valve. Pressure transmitters and pressure gauges on the inlet and outlet piping connected to each vessel will measure and indicate pressure both locally and in the control room. Control interlocks with the well pumps and booster pumps will be used to prevent system pressure from exceeding the pressure rating of the lowest rated system component.

Production Bleed RO System (Deep Disposal Well Option)

The production bleed RO system will be designed to accommodate the production bleed flow, rejecting approximately 30 percent of the flow as brine and returning 70 percent of the flow as permeate. The production bleed RO system will be a packaged system including feed conditioning, filtration, membranes, and control system.

Booster Pumps

Booster pumps may be used to convey pregnant lixiviant to the SF or CPP, and to convey barren lixiviant from the SF or CPP to the well field. These pumps will be in-line centrifugal pumps, and will each have the capacity to pump 50 percent of the design flow. The pumps will be equipped with pressure indicators on the discharge lines, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room located in the SF or CPP, respectively. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.3 Resin Transfer

Resin will be transferred out of IX vessels at the CPP and SF to the elution circuit where it will be regenerated by contacting it with concentrated salt solutions. The concentrated salt solution displaces the UDC and UTC and replaces them with chloride or carbonate ions. The regenerated resin will be then transferred back to IX vessels.

At the CPP, resin transfer will be accomplished by pumping water into the top of the IX vessel with the bottom discharge valve open. This will force the resin to flow out of the vessel into the transfer pipe. The resin and water will be pumped via the transfer piping to one of two elevated shaker screens. The shaker screens will be inclined, vibrating screens which will separate transfer water, loaded resin, and waste into separate streams. The transfer water will pass through the screens and flow by gravity into a collection tank which feeds the resin transfer pumps. The loaded resin will drop into one of four elution columns to be regenerated. The oversized or undersized solid waste from the shaker screens will consist of broken resin beads, silt and sand from the wells, and scale removed from the resin, and will collect in a hopper to be periodically removed and drummed for disposal.

Following elution of the resin, the transfer process will be reversed. Water will be pumped into the top of the elution column with the bottom discharge valve open. This will force the resin out of the column and into the resin transfer piping. The resin and water will be pumped back to the IX vessel where they will enter through a nozzle on the side of the vessel. The resin transfer water will exit the vessel through the bottom liquid distributor and flow back to the resin transfer water tank. The resin will remain in the IX vessel because it will not be able to pass through the screen openings in the bottom liquid distributor.

At the SF, loaded resin will be transferred from the IX vessels to a tanker truck that enters the building (Figure 3.2-5). Resin transfer will be accomplished through resin transfer piping and hoses that connect the exchange vessels to the transfer truck. With the connections made and transfer valves opened, resin transfer water will be pumped into the top of the IX vessel with the bottom discharge valve of the vessel open. This will force the resin to flow out of the vessel and into the tanker truck. Water and resin will enter the tanker, and water will exit the tanker through a screened outlet port and be returned to the resin transfer water tank. The resin, which cannot pass the screen, will remain in the tanker. When the resin has been flushed from the vessel and piping, the excess transfer water is drained from the truck, the valves controlling the transfer will be closed and the hoses disconnected from the truck.

The truck will then transport the resin to the CPP where the truck will be connected via hoses to the resin transfer water headers. To transfer resin out of the tanker, water will be introduced to the tanker from the resin transfer water tank, and water and resin will flow out of the tanker to the vibrating screens described above. To transfer resin back into the tanker following elution, water and resin will be pumped out of the columns as described above, and routed into the tanker via the hose connections between the tanker and the resin transfer header. As with the transfer at the SF, the resin will remain in the tanker and the transfer water will return to the resin transfer water tank. When the tanker returns to the SF, the regenerated resin will be transferred back into the IX vessel using the same methods.

3.2.3.1 Resin Transfer Equipment

Equipment associated with the resin transfer system includes a resin transfer tanker truck, two shaker screens, a shaker screen water tank, a resin transfer water tank, and a resin transfer pump.

Resin Transfer Tanker Truck

Resin transfer tanker trucks will have one or more compartments with sloped bottoms and screened bottom outlet nozzles. Resin transfer tanker trucks will have a minimum capacity of 500 ft3 per compartment.

Shaker Screens

The shaker screens will be packaged units that allow adjustment of angle and motion to optimize separation. The screens will be installed on an elevated platform to allow resin to drop into the elution columns. Hoods will be constructed above each shaker screen. Each hood will be

connected to a vent header that will exhaust through a vent in the building roof to prevent radon accumulation inside the CPP.

Shaker Screen Water Tank

The shaker screen water tank will be a vertical cylindrical atmospheric tank with a cone bottom and flat cover. The tank will be constructed of fiberglass reinforced plastic (FRP) and will be elevated to allow gravity flow of water into the resin transfer water tank from the shaker screen. Waste solids from the resin transfer process will collect in the conical bottom of the tank and will be removed periodically and disposed. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The tank will be connected to a vent header which will exhaust through a vent on the building roof.

Resin Transfer Water Tank

The resin transfer water tank will have a capacity of approximately 12,000 gallons. This tank will be a vertical cylindrical atmospheric tank with a flat bottom and flat cover. The tank will be constructed of FRP, and will be approximately 13 ft in diameter with a height of 13 ft. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The tank will be connected to a vent header which exhausts through a vent on the building roof.

Resin Transfer Water Pump

The resin transfer water pump will have a capacity of approximately 300 gpm. This pump will be a horizontal, end-suction centrifugal pump and will be constructed of ductile iron. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.4 Elution

The elution process will remove the UDC and UTC from the resin and restore the resin to its chloride form to allow it to be put back into service to remove uranium from pregnant lixiviant. This process is represented by the following equations:

$$R_2UO_2(CO_3)_2 + 2C1^- \rightarrow 2\ RCl + UO_2(CO_3)_2^{-2}$$

$$R_4UO_2(CO_3)_3 + 4Cl^- \rightarrow 4RCl + UO2(CO_3)_3^{-4}$$

Elution will be a four-stage process that takes place in an elution column and will involve contacting the loaded resin with batches of eluant solution containing approximately 10 percent by weight sodium chloride and 2 percent by weight sodium carbonate. Each elution stage will strip the resin of additional uranium complex and further restore the exchange capacity of the resin. Following the final elution stage, more than 95 percent of the uranyl carbonate complex will have been removed from the resin.

In the first elution stage, intermediate eluant will be pumped from the intermediate eluant tank through the elution column, stripping approximately 80 percent of the uranyl carbonate ions from the resin. After exiting the column, this solution will be pumped into the rich eluate tank.

In the second elution stage, lean eluant will be pumped from the lean eluant tank through the elution column, stripping approximately 60 to 70 percent of the remaining uranyl carbonates from the resin. After exiting the column, this solution will be pumped into the empty intermediate eluant tank to be used as intermediate eluant in the processing of the next batch of loaded resin.

In the third elution stage, fresh eluant will be pumped from the fresh eluant tank through the elution column, stripping approximately 30 to 40 percent of the remaining uranyl carbonate ions from the resin. After exiting the column, this solution will be pumped into the lean eluant tank to be used as lean eluant in the processing of the next batch of loaded resin.

In the fourth and final elution stage, utility water will be pumped from the utility water tank through the elution column, displacing the eluant entrained in the resin. After exiting the column, the rinse water will be pumped into the fresh eluant tank. Saturated sodium chloride and sodium carbonate solutions will be pumped into the fresh eluant tank to make up the next batch of fresh eluant.

3.2.4.1 Elution System Equipment

Elution system equipment includes four elution columns, eight eluant/eluate tanks, and elution pumps.

Elution Columns

The four elution columns will be vertical cylindrical pressure vessels with dished heads. The vessels will be constructed of FRP. The vessels will be constructed according to ASME Section VIII specifications. Each vessel will be equipped with upper and lower flow distribution manifolds constructed of stainless steel pipe and slotted well screen. The elution columns will be designed to provide optimum contact time between eluant solutions and IX resin. These columns will be capable of being operated over a range of flowrates without loss of performance.

Each column will be equipped with a pressure relief valve and an air/vacuum release valve. Each column will also be equipped with a level indicator/transmitter which will measure and indicate level in the column both locally and in the control room. Pressure transmitters and pressure gauges on the inlet and outlet piping connected to each vessel will measure and indicate pressure both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof to minimize radon emissions within the CPP building.

Elution Tanks

There will be a total of 8 elution tanks in the CPP. These include two Fresh Eluant Tanks, two Lean Eluant Tanks, two Intermediate Eluant Tanks, and two Rich Eluate Tanks. Each elution tank will have a capacity of approximately 16,500 gallons. Each tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which will exhaust through a vent on the building roof to prevent radon accumulation inside the CPP building.

Elution Pumps

There will be a total of 10 elution pumps, each with a capacity of approximately 150 gpm. These pumps will be horizontal, end-suction centrifugal pumps and have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.5 Precipitation

The precipitation process will be designed to break the uranyl carbonate complex, precipitate the uranium as uranium peroxide, and settle the precipitated solids from the eluant solution. The precipitation process will be comprised of a series of chemical addition steps, each causing a specific change in the rich eluate solution.

Prior to beginning the precipitation process, the rich eluate transfer pump will be used to transfer the rich eluate from the rich eluate tank to the precipitation tank. The precipitation tank contents will be mixed via an agitator. The first stage of chemical addition will be to add sulfuric or hydrochloric acid to bring the pH down to a range of approximately 2-3 pH units. This change in pH will cause the uranyl carbonate complex to break, liberating carbon dioxide, which will be vented from the tank, as illustrated in the following chemical reaction.

$$UO_2(CO_3)_3^{-4} + 6H^+ \rightarrow UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

Following completion of CO2 evolution, sodium hydroxide will be added to raise the pH of the solution to between 4 and 5 pH units. When the pH has stabilized, hydrogen peroxide (H2O2) will be added to the solution to form insoluble uranium peroxide (UO4). Following addition of H2O2 , the agitator speed will be slowed down to promote crystal growth.

$$UO_2^{++} + H_2O_2 + 2H_20 \rightarrow UO_4 \bullet 2H_2O + 2H^+$$

After a precipitation period of up to 8 hours, sodium hydroxide will be added to raise the pH to approximately 7, and the contents of the precipitation tank will be pumped into the thickener using the precipitation transfer pumps.

3.2.5.1 Precipitation System Equipment

Precipitation system equipment will include precipitation tanks, transfer pumps, and thickeners.

Precipitation Tanks

There will be two precipitation tanks in the CPP. Each precipitation tank will have a capacity of approximately 20,000 gallons. Each tank will be a vertical cylindrical atmospheric tank with sloped bottom and flat cover. Each tank will be constructed of FRP. Each tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be equipped with a pH sensor connected to a pH indicator/controller in the control room. Each tank will be connected to a vent header which will

exhaust through a vent on the building roof to prevent radon accumulation inside the CPP building.

Thickeners

There will be two gravity thickeners in the CPP. Each thickener will be a rubber lined 30-ft. diameter steel tank with conical bottom. The thickeners have a rake mechanism which has angled arms that match the angle of the conical bottom of the tank. As the rake rotates, the motion of the paddles through the sludge blanket at the bottom of the thickener will express liquid out of the sludge and increases the solids content of the sludge. The liquid and suspended solids from the precipitation tank will be introduced into the thickener via a center feed tube. The suspended solids will settle out of the liquid as it flows from the center of the thickener to the side overflow launders. Clarified effluent will spill over a weir into the launders, and from there it will be collected and directed to the solids removal tank in the wastewater system.

Precipitation Transfer Pumps

There will be 2 precipitation transfer pumps, each with a capacity of approximately 200 gpm. Each pump will be a horizontal, end-suction centrifugal pump and has wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room.

Pressure Filtration

The pressure filtration system will be designed to dewater, rinse, and air dry the precipitated uranium peroxide present in the thickener underflow. The thickener underflow will be pumped by progressive cavity pumps into the two horizontal plate and frame filter presses where the solids content of the thickener underflow will be increased to approximately 60 percent by weight by first pressing the slurry between filtration diaphragm plates. Then the press pressure will be released and utility water will be pumped through the filter cake to remove impurities, particularly chloride. The plates will then be pressed again, followed by introducing compressed air to the pressed cake to further dry it. Upon completion of the drying cycle, the filter cake will be conveyed out of each filter chamber on the moving filter cloth and directed into the two filter press cake chutes. An enclosed inclined screw conveyor will convey the filter cake from the shoot to the feed inlet on one of the two vacuum dryers.

Wastewater exiting the filter press will flow into a sump and be pumped into the solids removal tank in the wastewater system.

In order to minimize the potential for fugitive dust particles, the filter presses will located in a separate room and each will be enclosed in an interlocked cover. The connections between the cake chutes and enclosed screw conveyors will be gasketed and flanged, the screw conveyors will be enclosed, and the connection between each screw conveyor and knife gate valve on the dryer feed inlet will be gasketed and flanged. HVAC considerations for this system are discussed in Section 3.2.11 below.

The filter presses will be equipped with pressure gauges that indicate the pressure in the hydraulic system, as well as an inlet pressure indicator transmitter. Inlet pressure will be interlocked with the feed pumps to prevent over-pressurization of the filter presses.

3.2.6 Drying and Packaging

The uranium peroxide filter cake will be dried in a rotary vacuum dryer at approximately 250°F. Angled paddles attached to a central shaft in the dryer will agitate the filter cake to promote even drying. The dryers will be heated with a thermal fluid (e.g., MultiTherm IG-4) that will be circulated through the dryer shell and the rotating central shaft. The thermal fluid (TF) will be heated by an electric heater with a pump for circulating the TF through the shell and central shaft of the dryer.

The vapor pulled from the dryer by the vacuum pump will be filtered through a baghouse filter located on the top of the dryer to remove particles down to approximately 1 micron in size. The vapor exiting the baghouse will be cooled using a condenser to remove water vapor and remaining small particles. Liquid ring vacuum pumps will provide the vacuum source. The water that will be collected from the condenser will be pumped to the solids removal tank in the wastewater system.

Two rotary vacuum dryers, baghouses, and packaging equipment will be housed in a separate room in the CPP. The vacuum pump and condenser system for each dryer, and the TF heaters and pumps will be located in the main CPP area to provide access for operation and maintenance. The vacuum pumps will discharge to the dryer room. Air in the dryer and packaging room will be monitored routinely for airborne dust. A dedicated air handler equipped with HEPA filters will ventilate the dryer and packaging room and will provide an additional level of controlling particulate emissions.

3.2.6.1 Drying and Packaging Equipment

The major components of the system include the vacuum dryers, baghouses, vacuum pump and condenser systems, thermal fluid heaters, and the packaging system.

Vacuum Dryer

There will be two vacuum dryers in the CPP. The dryer chambers will be designed for 450° F and full vacuum, and a production rate of 2200 dry pounds per day. The dryer chambers will be heated externally and fitted with rotating paddles attached to a central shaft to agitate the yellowcake. The chamber will have a top port for loading the dewatered filter cake and a bottom port for unloading the dry powder. A port will be provided for pulling vapors through the baghouse using the vacuum pump.

Refer to Section 4.1.2.2 for monitoring and logging procedures that will be used to ensure adequate vacuum levels are maintained.

Baghouse Filter

Each dryer will be connected to a baghouse filter enclosure. Each baghouse filter will have an integrated compressed air blow down system. The baghouse filters will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be discharged back to the drying chamber. The bag house filters will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system.

Vacuum Pump and Condenser System

The vacuum pump and condenser systems will include water sealed liquid ring vacuum pumps with seal water reservoirs, seal water cooling heat exchangers, condensers, condensate receivers, and condensate pumps. Three of these systems will be provided, with two being on line and the third acting as a backup unit. The suction side of the vacuum pump will pull vapors from the vacuum dryer through the baghouse and then through the condenser. Seal water will be cooled in a heat exchanger as it flows to the vacuum pump head. Cooling water from the cooling tower will be circulated through the condenser and the seal water heat exchanger. Condensate from the condenser will flow into a receiver tank constructed of 304 SS. When the receiver tank is full as sensed by a level switch, a condensate transfer pump will pump the condensate to the solids removal tank in the wastewater system.

Thermal Fluid Heaters

Packaged electrical thermal fluid heaters will be used to circulate hot thermal fluid through the shell and central shaft of the rotary dryers. Each thermal fluid heater will be equipped with a circulating pump to circulate the thermal fluid through the dryer and back to the heater.

Packaging System

The packaging system will be operated on a batch basis and will include conveyors, scales, and a spray booth. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a knife gate valve on the bottom port of the dryer into 55-gallon steel drums. Particulate emissions will be minimized by use a sealed hood that fits on the top of the drum. A weigh scale will be used to determine when a drum is full. A conveyor system will allow drums from both dryers to be moved from beneath the dryer to an enclosed spray booth where each drum will be rinsed with a spray of water. The conveyor system will then move the drum to a scanning station where the drum will be hand scanned for radioactivity and then placed in the storage area or rinsed further.

3.2.7 Restoration

The restoration system is designed to extract, store, and distribute makeup water for restoration of well fields. The restoration system may also incorporate a reverse osmosis (RO) system to remove TDS from extracted water and return low TDS permeate to the restoration system. Reject from the reverse osmosis system, if utilized will be routed to a high TDS wastewater system.

3.2.7.1 Restoration System Equipment

Restoration system equipment includes a restoration water tank, a restoration makeup water pump, and a restoration RO system. Each SF will be equipped for restoration of post-production well fields.

Restoration Water Tank

The restoration water tank will be constructed of FRP. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Restoration Makeup Water Pump

The restoration makeup water pump will have wetted parts constructed of ductile iron. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

Restoration Reverse Osmosis System

The restoration RO system at each site will be a packaged system capable of treating approximately 500 gpm and producing a permeate stream and a reject brine. This system will include necessary pretreatment, including multi-media or sand filters and feed conditioning.

3.2.8 Chemical Storage and Feeding Systems

The ISL process requires chemical storage and feeding systems to store and dose chemicals at various stages in the extraction, processing, and waste treatment processes. The chemicals to be utilized in uranium processing at the project are listed in Table 3.2-1. The potential for any of these chemicals to impact radiological safety is variable in likelihood and consequence. Chemicals that have the potential to impact radiological safety include hydrochloric acid, sulfuric acid, hydrogen peroxide, and sodium hydroxide. Oxygen, because of its ability to support combustion, also requires special handling. In all instances, process controls and preventative safety measures minimize the risk of increased radiological exposure or release. Each chemical storage and feeding system will be designed to safely store and accurately deliver process chemicals to the process delivery points. All chemical storage tanks will be clearly labeled to identify contents. Design criteria for chemical storage and feeding systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Powertech (USA) employees and members of the public, both with regard to the specific chemicals and with regard to the potential release of radioactive materials in the event of an accident.

Table 3.2-1: Process-related Chemicals and Quantities Stored On-site

Chemical Name	No. Tanks	Unit Storage Capacity	Units	Usage Rate ton/yr	Hazard Classification
Burdock CPP and Well Fields					
Sodium Chloride (NaCl)	2	20,000	gal	2,250	Non-flammable
Sodium Carbonate (Na_2CO_3) i.e., Soda Ash	1	20,000	gal	450	Non-flammable
Hydrochloric Acid (HCl, 32%, or Sulfuric Acid (H_2SO_4 93%)	1	7,000	gal	487	Toxic, reactive, corrosive
Sodium Hydroxide (NaOH 50%)	1	7,000	gal	446	Toxic, reactive, corrosive
Hydrogen Peroxide (H_2O_2 50%)	1	7,000	gal	177	Oxidizer, irritant, corrosive
Oxygen (O_2, liquid)	1	11,000	gal	979	Cryogenic, oxidizer
Carbon Dioxide (CO_2)	1	6,000	gal	245	Asphyxiant, freezing hazard
Barium Chloride ($BaCl_2$)	1	275	50-kg sacks	7	Toxic, non-flammable
Dewey Satellite Facility and Well Fields					
Oxygen (O_2, liquid)	1	11,000	gal	653	Cryogenic, oxidizer
Carbon Dioxide	1	6,000	gal	163	Asphyxiant, freezing hazard
Barium Chloride	1	138	50-kg sacks	7	Toxic, non-flammable

Any negative impact to radiological safety from use of these chemicals would be due to accidents, improper use, or human error. Nevertheless, these chemicals would only indirectly cause a radiological hazard as they do not contain radiological materials themselves.

Figures 3.2-4 and 3.2-5 show the storage locations of all chemicals used in uranium processing, with the exception of oxygen. Oxygen will be stored as cryogenic liquid in tanks located in the well field areas. Oxygen storage tanks will be located near but at a safe distance from header houses as required by NFPA and OSHA standards. Figures 3.2-7 and 3.2-8 depict the potential oxygen storage tank locations for the Burdock and Dewey initial well fields, respectively.

At the CPP, the chemicals include sulfuric and/or hydrochloric acid, hydrogen peroxide, and sodium hydroxide. Of these, only hydrogen peroxide presents a fire hazard if it comes in contact with combustible materials. These chemicals are corrosive and reactive. Areas within the CPP and chemical storage areas will be provided with secondary containment consisting of concrete curbs around the floor perimeters. Curbs will also divide areas to prevent mixing of incompatible fluids in the event of a leak or spill. Concrete floors, secondary containment, and sumps in areas where corrosive fluids could be spilled will be coated with corrosion resistant materials as recommended by the manufacturer. Thickeners will be plain carbon steel construction lined with chlorobutyl or bromobutyl rubber and capable of operating at 175° F in a highly acidic environment. Elastomeric linings will also be used to resist abrasion from the slurries in these tanks. All slurry piping will use materials that are abrasion and corrosion resistant and solution piping will be appropriately corrosion resistant. Tanks holding process solutions will be constructed from FRP using resins and liners appropriate to the conditions as recommended by the manufacturers.

At the Dewey Satellite Facility, none of the chemicals listed above will be present. The only chemicals to be stored and used at the Satellite Facility will be relatively small quantities of RO pretreatment chemicals such as antiscalant.

3.2.8.1 Sodium Chloride Storage

Sodium chloride will be used to make up fresh eluant and will be stored in tanks as a saturated solution (approximately 26 percent by weight) in equilibrium with a bed of crystals in each storage tank. Dry sodium chloride will be delivered by truck and will be blown into the storage tanks using air pressure.

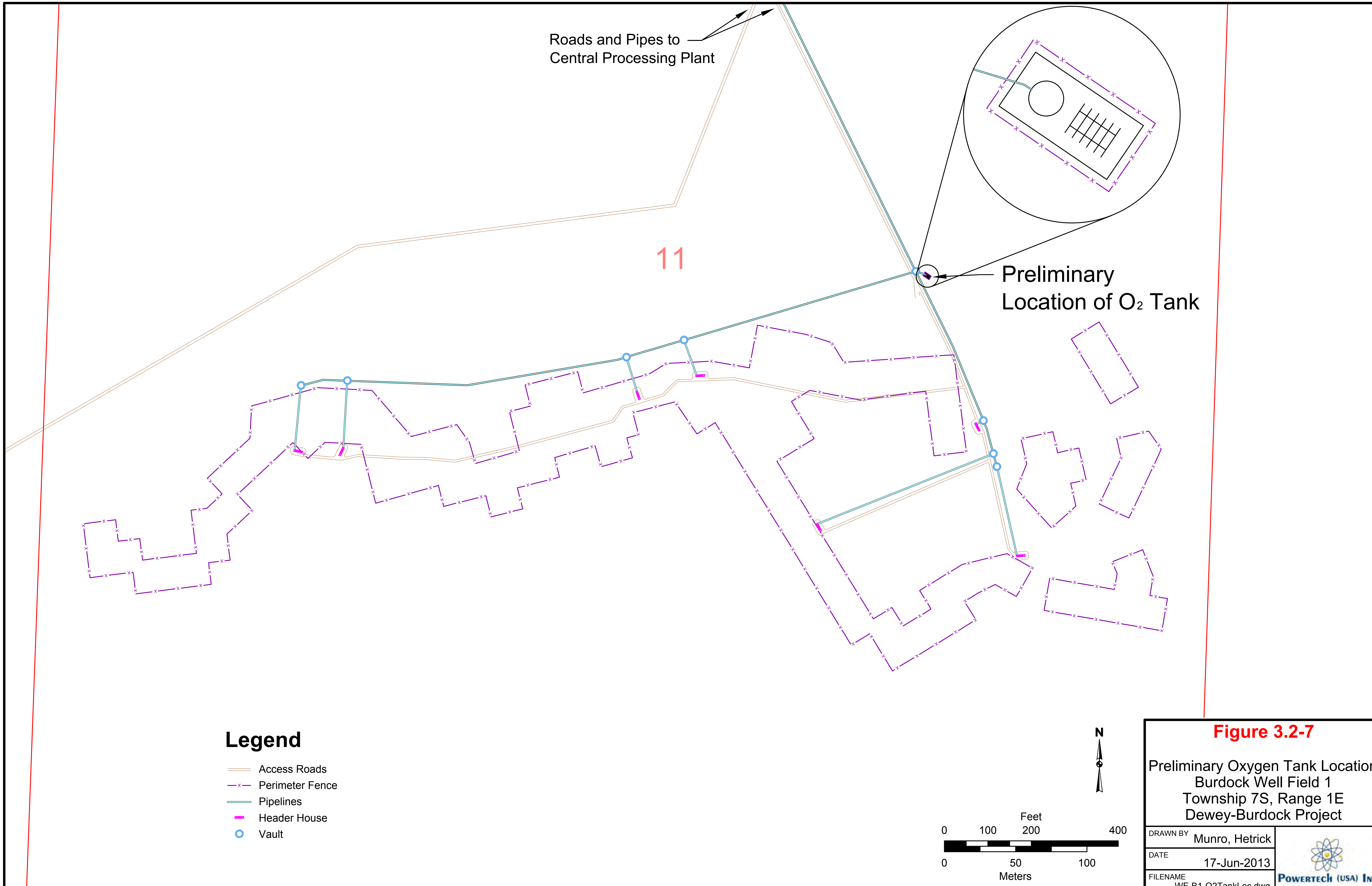


Figure 3.2-7

Preliminary Oxygen Tank Location
Burdock Well Field 1
Township 7S, Range 1E
Dewey-Burdock Project

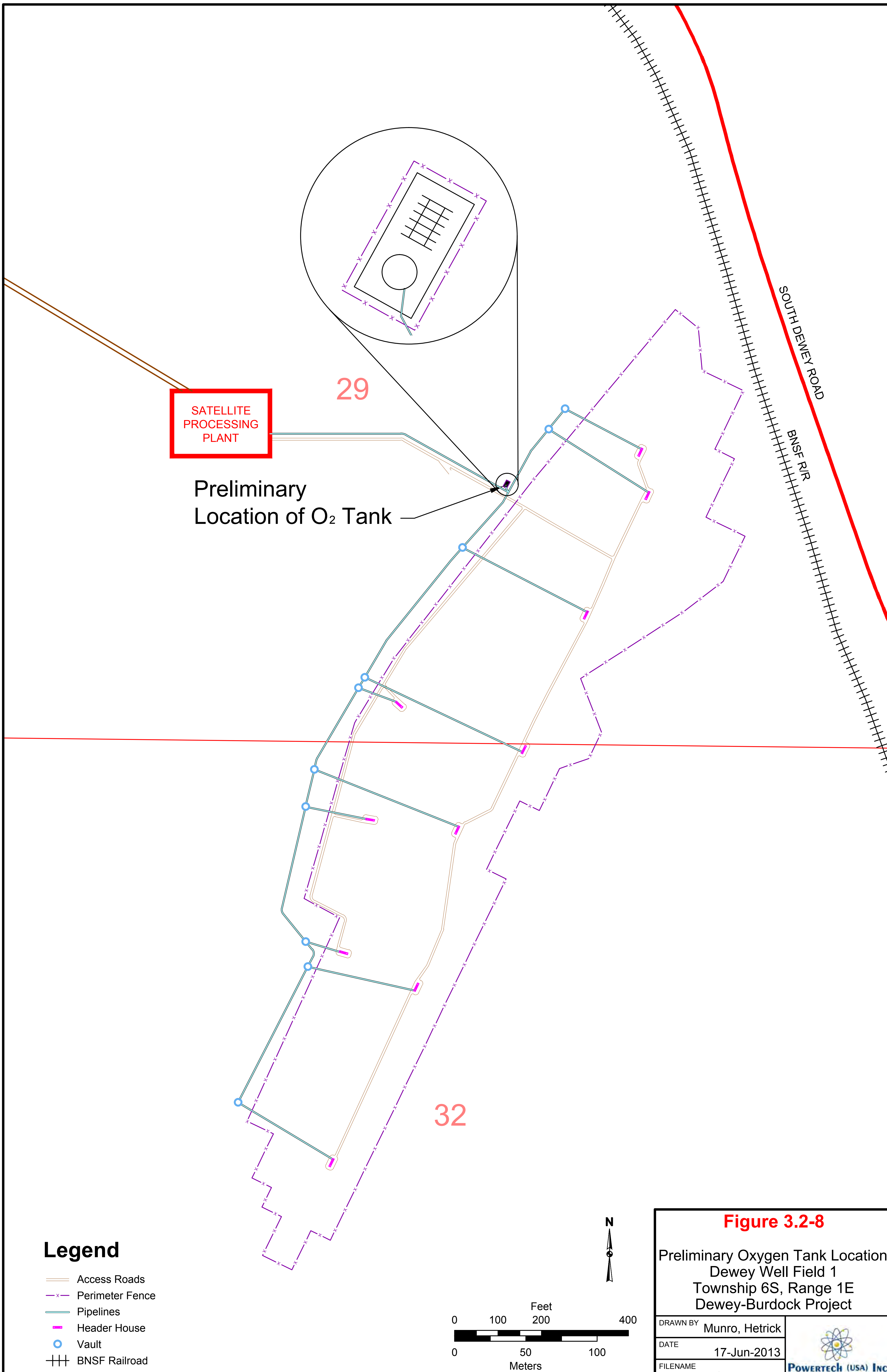


Figure 3.2-8

Preliminary Oxygen Tank Location
Dewey Well Field 1
Township 6S, Range 1E
Dewey-Burdock Project

Sodium Chloride Tanks

There will be two Sodium Chloride Tanks, each with a capacity of approximately 20,000 gallons. These tanks will be a vertical cylindrical atmospheric tank with a sloped bottom and flat cover. Each tank will be constructed of FRP, and will be approximately 13 ft in diameter with a height of 20 ft. Each tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof, and will be equipped with a scrubber to prevent emission of particulates during truck unloading.

Sodium Chloride Pumps

There will be two sodium chloride pumps that will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.2 Sodium Carbonate Storage

Sodium carbonate will be used to make up fresh eluant and will be stored in tanks as a saturated solution in equilibrium with a bed of crystals in the storage tank. Sodium carbonate solution must be kept above 140 F to prevent precipitation in the tank and piping. This will be accomplished by heating the water added to the tank, and continuously circulating liquid from the tank through a heat exchanger. An electric heater will be used to heat a thermal fluid to heat the exchanger. Dry sodium carbonate will be delivered by truck and will be blown into the storage tanks using air pressure.

Sodium Carbonate Tank

The sodium carbonate tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The tank will be connected to a vent header which exhausts through a vent on the building roof, and will be equipped with a scrubber to prevent emission of particulates during truck unloading.

Sodium Carbonate Pumps

The sodium carbonate pumps will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.3 Acid Storage and Feeding System

Sulfuric acid and/or hydrochloric acid will be used in the precipitation circuit of the CPP to break down the uranium carbonate complexes. The hazards associated with use and storage of acid include corrosiveness, toxicity to tissue, and reactivity with other chemicals at the project such as sodium carbonate and water. Acid storage tanks will be isolated from other chemicals to reduce the risk of reactions. The acid storage and feeding system will include one or more storage tanks and delivery pumps. The storage tank will be located adjacent to the CPP in the chemical storage area. The chemical storage area will include a lined concrete secondary containment basin designed to contain at least 110 percent of the largest tank volume plus a 25 year, 24 hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The acid feed pump will be located inside the building, directly adjacent to the storage tank.

Acid Storage Tank

The acid storage tank will be designed to store sulfuric or hydrochloric acid. The tank will be constructed of HDPE, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The acid storage tank will be located outside the CPP as shown in Figure 3.2-4. The acid storage tank will be vented directly to the atmosphere. Sulfuric acid will be purchased and stored as standard commercial grade concentrated acid (approximately 93% H_2SO_4 by weight). The storage tank will be made either of carbon steel or ultra-high-molecular-weight, cross linked polyethylene. Piping and pump material will be chosen based on compatibility. The freezing point of 93% sulfuric acid is approximately -28.9°C (-20°F); therefore, freeze protection of the storage tank and outside piping (insulation and heat tracing) will be used. Powertech (USA) will develop and implement an emergency response plan and emergency notification procedures in the event of an accidental release.

Acid Transfer Pump

The acid feed pump will have wetted parts constructed of FRP. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.4 Sodium Hydroxide Storage and Feeding System

The sodium hydroxide system will include a storage tank and delivery pump. The storage tank will be located adjacent to the CPP in the chemical storage area in a concrete secondary containment basin designed to contain at least 110 percent of the tank volume plus a 25-year, 24-hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The sodium hydroxide feed pump will be located inside the building, directly adjacent to the storage

tank. Sodium hydroxide will be purchased as aqueous caustic soda, and will be pumped directly into the storage tank from the supplier's tanker trucks.

Sodium Hydroxide Storage Tank

The sodium hydroxide storage tank will be constructed of carbon steel. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Sodium Hydroxide Pump

The sodium hydroxide feed pump will have wetted parts constructed of FRP. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.5 Hydrogen Peroxide Storage and Feeding System

The hydrogen peroxide system will include a storage tank and delivery pump. The storage tank will be located adjacent to the CPP in the chemical storage area in a concrete secondary containment basin designed to contain at least 110 percent of the tank volume plus a 25 year, 24 hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The site will have storage facilities for 7,000 gallons (70,000 pounds) of 50% H_2O_2. Hydrogen peroxide is a strong oxidizer, can be very reactive and is easily decomposable. Its hazardous decomposition products include oxygen, heat, and steam.

The hydrogen peroxide feed pump will be located inside the building, directly adjacent to the storage tank.

Hydrogen Peroxide Storage Tank

The hydrogen peroxide storage tank will be constructed of HDPE, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Hydrogen Peroxide Pump

The hydrogen peroxide feed pump will have wetted parts constructed of FRP. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control

room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.6 Oxygen Storage and Feeding System

Liquid oxygen will be present within the well fields. The primary hazard associated with oxygen is fire since it is a strong oxidizer in the presence of combustible materials. To reduce the risk of an accident that could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored near the well fields, so that in the event of an accidental release the gas would disperse and not cause a fire hazard to project equipment or infrastructure. Where above-ground oxygen storage or conveyance facilities exist, barriers will be used to prevent impacts from mobile equipment. Oxygen conveyance pipelines will be surveyed and marked with tracer wire to make them locatable by field personnel during excavation activities. A fire within a header house, where the oxygen is metered into separate injection lines, could damage equipment and instrumentation within the header house but would be unlikely to result in a spill of injection or recovery fluids. If a spill of lixiviant were to occur, well field personnel will have been trained in emergency procedures for responding to well field spills containing radiological materials. Oxygen will be stored in storage vessels designed, fabricated, tested, and inspected in accordance with the ASME Boiler and Pressure Vessel Code. Oxygen storage vessels will be equipped with safety relief devices and will be located at least 25 feet from buildings or as required by applicable NFPA and OSHA standards. Oxygen will be delivered and stored as a cryogenic liquid and then conveyed to the injection point (either upstream of the injection manifold within the header house or at each well head) as a gas through piping made from appropriate materials. Oxygen storage and delivery systems will be designed and fabricated in accordance with NFPA 55 and OSHA standards for the installation of bulk oxygen systems on industrial premises (29 CFR 1910.104). To reduce the risk of an accident which could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored a sufficient distance from other infrastructure and storage areas. Facilities used to store oxygen will conform to standards detailed in NFPA 55. Typically, oxygen storage and dispensing systems will be leased from the bulk oxygen vendor. Conveyance systems for oxygen will be clean of oil and grease because these substances will burn violently if ignited in the presence of oxygen. The proper pressure relief devices, component isolation and barriers will also be employed. Cleaning of equipment used for delivering and storing oxygen will be done in accordance with CGA G4.1. The design and installation of the oxygen piping system will be done according to the requirements of CGA G4.4. Powertech (USA) will develop procedures that implement emergency response instructions for a spill or fire involving oxygen systems.

3.2.8.7 Carbon Dioxide Storage and Feeding System

The carbon dioxide storage and feeding system will be used to dissolve carbon dioxide into the pregnant lixiviant to improve recovery of uranium in the IX vessel. This system will be a vendor supplied packaged system including cryogenic tank, vaporizer, pressure gauges, and pressure relief devices.

3.2.8.8 Barium Chloride Storage and Feeding System

The barium chloride storage and feeding system includes a storage tank, agitator, and chemical metering pump. This system will be designed to dissolve solid barium chloride in water to make up the solution for feeding into the low TDS wastewater for radium precipitation. Barium chloride will be stored as palletized sacks at the locations shown on Figures 3.2-4 and 3.2-5.

3.2.8.9 Byproduct Storage

Prior to transportation to a licensed disposal facility, byproduct material will be stored in designated storage buildings (also referred to as “byproduct storage buildings”), one located at the CPP site and one located at the SF site. These buildings will consist of a concrete slab with a containment curb surrounding the perimeter. Storage of byproduct material will be within “roll-off” containers (bins) which are both liquid tight and fully enclosed. As each storage building can accommodate two 20 cubic yard bins, the volume of byproduct material could accumulate to 30 to 40 cubic yards at each of the two storage locations prior to transport. There are two bays in each storage building, each accessed by an overhead roll-up door and allowing exchange of containers necessary for transport to a licensed 11e.(2) disposal site. The concrete slabs will be designed to allow external decontamination of the roll-off bins prior to transport.

The byproduct storage buildings will allow for control of byproduct materials and specific segregation of these wastes from other non-11e.(2) wastes. Typically these wastes are expected to consist of contaminated used equipment parts, personal protective equipment, and wastes from cleanup of spills or other housekeeping activities. Other waste not in contact with the uranium production process will be disposed of in regular dumpsters situated at a separate location.

Containment of these byproduct wastes within a designated, fully enclosed building will allow for proper control of the materials, monitoring, and necessary restricted access. These measures will ensure best possible control of 11e.(2)solid and liquid wastes to minimize any potential exposures or contamination.

3.2.9 Utility Water

The utility water system will be used to extract, store, and distribute water for consumptive process uses and potable uses. Water will be extracted from wells drilled in a suitable formation in the vicinity of the SF and CPP. Water for potable uses will be chlorinated and stored in a pressurized tank.

3.2.9.1 Utility Water System Equipment

The utility water system equipment will include the utility water tank and utility water pumps.

Utility Water Tank

The utility water tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Utility Water Pump

The utility water pump will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.10 Wastewater

The wastewater system will be designed to receive, treat, and discharge wastewater generated at various stages of the process. The wastewater system will be divided into two main categories of

wastewater, high TDS wastewater, and low TDS wastewater. High TDS wastewater consists of waste eluant brine from the CPP and the reject streams from process bleed or restoration reverse osmosis systems if these systems are in use. Low TDS water sources include process bleed and extracted restoration water that have not been concentrated by a reverse osmosis process.

High TDS wastewater will flow by gravity from the solids removal tank to the high TDS wastewater tank. This wastewater will then be pumped to the liquid waste disposal system.

Low TDS wastewater will be collected in the low TDS wastewater tank and then pumped to a radium precipitation tank where barium chloride will be added to co-precipitate barium and radium sulfates. Treated wastewater will flow from the radium precipitation tank to the radium settling ponds for removal of the precipitate by settling.

3.2.10.1 Wastewater System Equipment

Wastewater system equipment includes the solids removal tank, the high TDS wastewater tank, the low TDS wastewater tank, the wastewater pumps, the radium precipitation tank and agitator.

Solids Removal Tank

The Solids Removal Tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof.

High TDS Wastewater Tank

The High TDS Wastewater Tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof.

Low TDS Wastewater Tank

The Low TDS Wastewater Tank will be constructed of FRP, and will equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Wastewater Pumps

Wastewater pumps will be provided for both high TDS wastewater and for low TDS wastewater, as needed, depending on the processing option selected in the final design. Each pump will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

Radium Precipitation Tank

The radium precipitation tank will be used to add barium chloride to the wastewater and provide thorough mixing prior to discharge to the radium settling ponds.

3.2.11 HVAC System

The heating, ventilating and air conditioning (HVAC) systems in the SF and CPP will be designed to provide routine heating, cooling and required air changes in occupied areas, as well as mitigate the potential for human exposure to radionuclides. The primary exposure concerns will be radon gas and uranium oxide dust or particulates.

The HVAC system for the main plant area will be designed both for controlling the temperature in the main plant area, and for preventing the buildup of fugitive radon emissions by ensuring a minimum number of air changes.

Radon gas is a daughter product of radium, which is present in the orebody, and thus is mobilized and dissolved into the pregnant lixiviant during production. The potential for radon emissions from the process arises when the pressurized flow from the extraction wells and booster pumps is exposed to atmospheric pressure. The two process systems with the potential for radon emissions are the IX vessels via the air/vacuum relief valves, and the shaker screens where the loaded resin and resin transfer water will be pumped onto an open screen at atmospheric pressure.

The shaker screens will each have a dedicated vent hood directly overhead. The vent hoods will be connected to an exhaust fan designed to create sufficient air flow and velocity to minimize the emission of radon in the vicinity of the shaker screens. The exhaust fans will discharge the air through a vent in the roof of the building. The vent will be located away from air intakes for the building.

Systems that have the potential to emit dust particles containing uranium include the filter presses, the dryers, and the drum filling stations.

The filter presses will be installed in a dedicated filtration room, and the vacuum dryers will be installed in a dedicated dryer room. These two rooms will be serviced with dedicated HVAC equipment that includes particulate filtration to minimize the potential for personnel exposure within the rooms and to prevent the emission of particles.

3.2.12 Instrumentation and Control

Powertech (USA) will install automated control and data recording systems at the Dewey Satellite Facility and the Burdock CPP which will provide centralized monitoring and control of the process variables including the flows and pressures of production, injection, and waste streams. The systems will include alarms and automatic shutoffs to detect and control a potential release or spill.

Pressure and flow sensors will be installed, for the purpose of leak detection, on the main trunklines that connect the CPP and Satellite Facility to the well fields. In addition, flow rates of each production well and each injection well will be automatically measured. Measurements will be collected and transmitted to both the CPP and Satellite Facility control systems. Should pressures or flows fluctuate outside of normal operating ranges, alarms will provide immediate warning to operators which will result in a timely response and appropriate corrective action.

Both external and internal shutdown controls will be installed at each header house to provide for operator safety and spill control. The external and internal shutdown controls are designed for automatic and remote shutdown of each header house. In the event of a header house shutdown, an alarm will occur and the flows of all injection and production wells in that header house will be automatically stopped. The alarm will activate a blinking light on the outside of the header house and will cause an alarm signal to be sent to the CPP and Satellite Facility control rooms.

An external header house shutdown will activate an electrical disconnect switch located on the outside of the header house or at the transformer pole which will shut down all electrical power to the header house. This will mitigate potential electrical hazards while de-energizing the header house and operating equipment. The production pumps will be de-energized which will result in flow stopping from all production wells. A control valve that will close when de-energized will be used on the injection header, which will stop the flow to all injection wells.

Internal shutdown controls will not involve de-energization of the header house but will result in the same alarm condition and shutdown of flow to all production and injection wells feeding the header house.

Each header house will also include a sump equipped with a water level sensor so that if a leak occurs, and the water level approaches a preset level, the sensors will cause an automatic shutdown of the header house. A pressure switch will be installed on the injection header to ensure that fluid pressures do not exceed the mechanical integrity test pressures of the injection wells served by that header house. If the injection pressure reaches the maximum set value in the pressure switch, an automatic header house shutdown will occur. Downhole pressure transducers will be installed in all monitor wells for the measurement of potentiometric head. These instruments will alert operators to any significant change in the water levels within the monitor wells to provide an early warning of a potential lixiviant excursion. Operators may then follow standard operating procedures to make adjustments to well field production and/or injection flow rates to avoid an excursion due to any unbalanced flow condition in a well field.

If an excursion or pipeline leak were to occur, procedures will be in place to address and correct it. Well field operators will conduct daily visual inspections of well field facilities, including header houses and all visible pipes, connections, and fittings. Operating flow rates and pressures of all injection wells, production wells, and associated buried piping systems will also be monitored and recorded on a daily basis. The CPP and Satellite Facility control rooms will both receive the pressure and flow data transmitted from the well fields, trunklines, and header houses. This information will provide the plant operators access to instantaneous data on well field operating conditions, enabling them to respond appropriately to unexpected or upset conditions, and allow them to direct well field operators to specific locations where immediate attention is needed.

A detailed description of the deep disposal wells operation and control is included in Section 2.K, "Injection Procedures," of Appendix 2.7-L, which includes the Class V UIC permit application. The automated control system on the Class V deep disposal wells will include control switches to alert the operator if certain operating conditions are encountered. A high injection pressure switch (set below the permitted maximum) and a low annulus differential pressure switch (set above the permitted minimum) will shut off injection pump power and will alert the operator so that the well can be fully isolated and secured. The alarm will sound in the central control room of the CPP and/or Satellite Facility, whichever is nearer. In the event that any of the permit condition related set points are exceeded, injection operations will cease

immediately until the problem is identified and corrected. The system will then be manually restarted by an operator when operating parameter compliance is verified.

3.2.13 Backup Power

Backup generators will be installed to maintain continuous instrumentation monitoring and alarms in the CPP, Satellite Facility, and well fields. Backup power will also be provided for lights and emergency exits.

Loss of power to the project site will cause production wells to stop operating, resulting in shutdown of all production and injection flows. This condition avoids flow imbalance within the well fields, but a well field bleed would not be maintained during the power failure. The time span for the aquifer to recover from operational drawdown back to its natural groundwater gradient is much longer than the duration of a typical power outage. Since lixiviant would not begin to travel to the monitoring ring until the cone of depression caused by the bleed had recovered and groundwater had returned to its natural gradient, excursions are very unlikely within the short time period of a typical power outage.

The likelihood of a long-duration regional power outage has been considerably reduced by passage of the Energy Policy Act of 2005. This act created the North American Electric Reliability Corporation (NERC) to develop and enforce compliance with mandatory reliability standards in the U.S. NERC's standards are mandatory and enforceable throughout the 50 United States and several provinces in Canada. The major interconnections which cover most of the continental U.S. and Canada include the Eastern Interconnection (most of eastern North America) and the Western Interconnection (Rocky Mountains to the Pacific Coast). The Eastern Interconnection is tied to the Western Interconnection via high voltage DC transmission facilities.

The Dewey-Burdock project area is in the Western Interconnection, but very close to the boundary between the Eastern and Western Interconnections. Because of the reliability added since NERC was created, it is difficult to conceive of a natural event that would cause loss of electric power for an extended period of time. Tornadoes, blizzards or freezing rain can knock out power generating or transmitting facilities. Transmission facilities can be replaced fairly quickly (relative to groundwater flow rates) and power sources can be substituted through the NERC interconnection.

Thus, power outages in the project area would not be likely to last more than a few days or weeks under most conceivable scenarios. The project area is in fairly close proximity to the Powder River Basin area in northeastern Wyoming, home to several coal-fired and gas turbine

generating facilities and industrial activities including oil and gas production and very large surface coal mines. Proximity to this region would facilitate acquisition of portable generators to keep the CPP and well field facilities operating until normal power supplies could be restored. Powertech (USA) will have temporary generators to operate well field pumps sufficient to maintain a cone of depression within the well field. These will be used if power outages occur with expected duration of more than a few weeks. Two or more small portable generators will provide sufficient energy to maintain a bleed sufficient to prevent excursions.

Shutdown due to power failure during winter months is not expected to be problematic because well field pipelines will be buried below the frost line. Heating of the Satellite Facility and CPP will use propane or natural gas and will require little or no power to operate.

3.3 OSHA Design Criteria

In addition to the design criteria discussed in the preceding subsections worker health and safety measures identified in 29 CFR Part 1910 will be incorporated into design of the ISL production and processing facilities, as discussed below.

- Walking and working surfaces (Subpart D) - Aisles, passageways, and storage areas will be designed to be free of obstruction such that emergency egress will not be hindered. Wet areas in the plant will be provided with drainage, platforms, mats, or other dry walking surfaces, as necessary. All open-sided platforms or other working areas greater

than 4 feet high will be equipped with standard railings. Flights of stairs more than 4 risers high will be equipped with standard hand railings in accordance with OSHA requirements.

- Means of egress (Subpart E) – Building will be designed and maintained to facilitate emergency egress. Exits will be clearly marked with illuminated exit signs.
- Occupational Health and Environmental Control (Subpart G) – Facilities will be designed with adequate ventilation systems to control worker exposure to vapors and temperature extremes. Noise will be minimized using engineering and administrative controls to ensure worker noise exposures are maintained below the permissible limits. As necessary, air compressors will be isolated to minimize noise levels within the processing facilities.
- Hazardous Materials (Subpart H) –Acid, caustic, and hydrogen peroxide storage areas will be individually curbed to provide secondary containment for each chemical. Sodium chloride, sodium carbonate, and barium chloride storage tanks will also have secondary containment, but do not need to be individually segregated. Operators will be provided hazard communication training, will have an MSDS onsite for these chemicals, and will have appropriate personal protective equipment (PPE) available for tank system maintenance and spill cleanup. An emergency eyewash/shower will be located adjacent to the storage areas. Spill response procedures will be included in the plant operating procedures. If used, flammable materials will be stored in the flammable storage locker.
- Personal Protective Equipment (PPE) (Subpart I) - The standards associated with respiratory, electrical, head, foot, and eye protection will apply. A workplace hazard assessment will be performed and documented. The requirement for PPE will be minimized by engineering and administrative controls that will be used to mitigate identified hazards. PPE will be used only to supplement these controls when required to ensure protection of employees. PPE in the form of respiratory protective equipment will be mandatory for workers in areas where the use of process and engineering controls may not be adequate to maintain regulated exposure levels to airborne radioactive and/or toxic materials.
- General Environmental Controls (Subpart J) - The general sanitation requirements for fixed facilities are applicable to the treatment facility. A restroom with a toilet and sink serviced by potable water will be provided. Fire systems and physical hazards will be color coded in accordance with subpart requirements. In addition to OSHA requirements, piping and facilities systems will be labeled.
- Medical and First Aid (Subpart K) - Plant operators will be trained in first aid and cardiopulmonary resuscitation. A first aid kit, eyewash, and emergency shower will be available.
- Fire Protection (Subpart L) – Portable fire extinguishers will be placed within the plant such that the maximum travel distance to an extinguisher will be less than 50 feet. Portable extinguishers will be inspected monthly and subjected to an annual maintenance check. In addition, the CPP, office building, maintenance area, and warehouse will be equipped with automatic fire sprinklers.

- Compressed Gas Equipment (Subpart M) - Compressed air piping, safety valves, and pressure gages will be constructed to American Society of Mechanical Engineers (ASME) standards. Safety valves will be inspected frequently and at regular intervals to determine operational condition.

- Materials Handling and Storage (Subpart N) - Safe clearances, secure storage, good housekeeping, and guarding of fall hazards will be used to protect workers. Forklift operators will be trained in accordance with 29 CFR 1910.178.

- Machinery and Machine Guarding (Subpart O) – Workers will be protected from physical hazards associated with grinding, fans, rotating shafts, and pinch points through guarding in conformance with subpart requirements.

- Electrical Installations (Subpart S) - All electrical installations will be made in conformance with the National Electric Code and will be designed and installed by competent persons. Ground-fault circuit interrupters will be used for power tools or for other circuits that are not part of the plant's permanent wiring. Operators will be trained in electrical safety.

- Toxic and Hazardous Substances (Subpart Z) - Potential chemical hazards at the plant include acids, caustics, oxidants, brine solutions, barium chloride, ammonium sulfate, uranium, radium, and radon gas. Fire notification to employees will be through voice communication. Fire Department response will be initiated through the 911 emergency telephone system. Workers will be provided hazard communication training and exposure monitoring will be conducted as necessary to ensure compliance with subpart requirements.

3.4 References for Uranium Processing

The uranium processing techniques proposed for this project are well documented in the literature and have been successfully implemented in the United States for the past 20 years.

3.5 Master Schedule

The proposed Dewey-Burdock ISL schedule is shown on Figure 1.9-1. The schedule is preliminary based on Powertech (USA)'s current knowledge of the recoverable reserves, land ownership, available water rights, and uranium market conditions. As the project is developed, the schedule will be updated accordingly. Refer to Figure 6.1-1 for a more detailed project schedule for individual well fields.

3.6 References

Center for Nuclear Waste Regulatory Analyses, NUREG/CR-6733, "*A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licenses*", 2001.

Compressed Gas Association, CGA G-4.1, "*Cleaning Equipment for Oxygen Service*", (CGA, 2000).

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US Nuclear Regulatory Commission, NUREG-1910, "*Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities*", US Nuclear Regulatory Commission, July, 2008.

4.0 Effluent Control Systems

4.1 Gaseous and Airborne Particulates

Powertech (USA) Inc. will conduct an airborne radiation monitoring program at the Dewey-Burdock facility which is consistent with the recommendations contained in RG 8.30 and will consist of monitoring radon decay products as well as airborne particulate monitoring. Powertech (USA) Inc. will also conduct an airborne effluent and environmental monitoring program during construction and operations consistent with recommendations in USNRC Regulatory Guide 4.14 "*Radiological Effluent and Environmental Monitoring at Uranium Mills*" (RG 4.14).

This section describes the expected radionuclide airborne emissions from the Dewey-Burdock uranium recovery facilities. Airborne emissions are categorized in two subsections, radon and radionuclide particulates. Potential sources of emissions and a basic description of monitoring for worker protection are described based on the design of the Dewey-Burdock ISL process as well as the emission controls systems that will be employed to maintain radionuclide effluents well below regulatory limits and as low as is reasonably achievable.

4.1.1 Radon

According to RG 8.30, measurements of radon decay products are a better measure for worker dose than measurements of radon. Therefore, measurements of radon decay products will be made in the facility. Working level (WL) measurements for radon decay products will be made on a monthly basis in areas where radon decay product concentrations are likely to exceed 0.03 WL as described in RG 8.30. The time, date, and state of operation of the equipment in the vicinity of the measurement will be recorded. Refer to section 5.0 Operations for a detailed description of the radon and radon decay products monitoring program and the proposed locations of monitoring stations.

The primary radioactive airborne effluent at the Dewey-Burdock ISL Facility will be radon-222 gas. Radon-222 is dissolved in the pregnant lixiviant that comes from the well field into the facility for separation of uranium. At the locations where the lixiviant solution is initially exposed to atmospheric pressure and ambient temperatures, radon gas will be evolved. These locations constitute primary release points and are expected to include the IX vessels into which the lixiviant is directed for loading of the uranium onto resin and the elevated shaker screens, which will receive the loaded resin prior to elution (NMA 2007, Brown 1982, 2007, 2008). The

IX vessels will normally operate as sealed, pressurized vessels, so that radon releases from the IX vessels will only occur during resin transfer operations. Dedicated local exhaust at the IX vessels and shaker screens will be directed to a manifold that is exhausted to the atmosphere outside the building via an induced draft fan. The primary release point will be located away from building intakes to prevent introducing exhausted radon back into the facility. Exhausting radon-222 gas to the atmosphere outside the plant minimizes opportunity for in-growth of radon particulate daughter products (progeny) in occupied work areas and therefore minimizes employee airborne exposure. Small amounts of radon-222 may also be released from the well field, solution spills, filter changes, 11e (2) by-product impoundment areas, reverse osmosis (RO) system operation during groundwater restoration, and maintenance activities. These secondary and/or infrequent additional releases would be quite small relative to radon dissolved in the pregnant lixiviant returning from underground. Radon releases associated with these secondary release points have been shown to be minor components of the overall facility radon-222 source term. (NMA 2007, Marple and Dziuk 1982, Brown 1980, 2007, 2008). An operational monitoring program will be utilized that is similar to the preoperational monitoring program set up to measure radionuclide particulates and radon -222 that may result in the atmosphere outside the building and other specified locations within the PAA.

The filters from air samplers operating continuously will be analyzed quarterly for natural uranium, thorium-230, radium-226, and lead-210. Samplers will have sensors to measure total air flow within a sampling period. Passive track-etch detectors will be deployed at each station for monitoring radon-222 on a quarterly basis. The maximum LLDs for the analyses will be consistent with the recommendations of RG 4.14. Additionally, effluent release points from the yellowcake dryer and packaging will be sampled quarterly. The grab samples will be isokinetic in nature and will be analyzed for natural uranium, thorium-230, radium-226, and lead-210. The maximum LLDs for the analyses will be consistent with recommendations of RG 4.14. Refer to section 5.0 Operations for a detailed description of the particulate air monitoring program and the proposed locations of monitoring stations.

The general HVAC system in the plant will further reduce employee exposure by removing radon from plant air and will be exhausted through a separate vent. This system will be connected via ductwork and manifolds to the eluant and precipitation tanks. Potential release points as well as general air in the plant will be routinely sampled for radon daughters to assure that concentration levels of radon and progeny are maintained as low as reasonably achievable (ALARA). Sampling and monitoring methods specific for radon progeny will be used (USNRC 2002a). Results of monitoring obtained during initial plant operation will be used to adjust

monitoring programs (location, frequency, etc), upgrade ventilation and/or other effluent control equipment as may be necessary.

Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. Redundancy of fans will minimize employee exposures should any single fan fail. Discharge points will be located away from building ventilation intakes to prevent introducing exhausted radon back into the facility (NRC 2002b). Airflow through any openings in the vessels will be from the process area into the vessel and then into the ventilation systems, maintaining negative flow into the vessel and controlling any releases. (note that the lixiviant circuit through IX will be a closed system; atmospheric conditions will initially be encountered during resin transfer at the shaker screens.) Tank ventilation of this type has been successfully utilized at other ISL facilities and proven to be an effective method for minimizing employee exposure. (Brown 1982, 2007, 2008)

The general building ventilation system will be designed to maintain air flow from the least likely to most likely process areas with potential for airborne releases and then exhaust to outside areas. Ventilation systems will exhaust outside the building and draw in fresh air. During favorable weather conditions, open doorways and convection vents in the roof will provide supplemental work area ventilation. Refer to Section 5.7.3.1 for additional discussion of radon released under such conditions.

Section 7.3 describes methods used to estimate potential radiological impacts resulting from planned activities to members of the public near the proposed facility. The CPP will be located near the center of the proposed license area, and the radon exhaust point will be located on or near the CPP roof. Based on use of modern ISR equipment, engineering controls such as building ventilation, and routine sampling and monitoring described below, radon effluent and worker exposure to radon decay products will be maintained at levels that are ALARA. As described in Section 5.7.7, the highest predicted Total Effective Dose Equivalent (TEDE) to a resident is 2.21 mrem per year for an adult, which is in compliance with the requirements of 10 CFR §20.1302.

To ensure effluents are ALARA, Powertech has committed to use sealed, pressurized, downflow IX vessels to limit routine radon-222 emissions from the CPP or Satellite Facility to resin transfer operations only. The radon emissions from the resin transfer operation will be exhausted using a dedicated ventilation system and released via a primary release point on or near the roof

of the facility. The primary release point will be located away from building intakes to prevent introducing exhausted radon back into the facility. The normal HVAC system will also aid in reducing radon-222 and decay product concentrations within the facility. Potential release points as well as general air in the plant will be routinely sampled for radon and decay products to assure concentration levels are maintained ALARA. Results of monitoring obtained during initial plant operation will be used to adjust monitoring programs and upgrade ventilation and/or other effluent control equipment as necessary.

4.1.2 Radionuclide Particulates

Since there will be no ore grinding at the facility, no monitoring of airborne uranium ore dust will be necessary. However, airborne yellowcake will be monitored at the facility. The facility will be drying yellowcake under low temperature (less than 400 ^{o}C). According to the footnotes of 10 CFR 20 Appendix B, yellowcake dried under low temperature should be considered soluble. Refer to Section 5.7.3.2 for additional explanation. Weekly 30 minute grab samples (low volume breathing zone samples) will be taken in airborne radioactivity areas. Breathing zone samples provide a better estimate of airborne particulate concentrations to which workers are exposed, resulting in a more representative estimate of actual intakes. The sensitivity of this method shall be at least 1 x 10^{-11} μCi / mL. Breathing zone samples will be taken during non-routine operations with potential for a worker to receive exposure to airborne yellowcake above 1 x 10^{-10} μCi / mL. Refer to section 5.0 Operations for a detailed description of the radon and radon decay products monitoring program and the proposed locations of monitoring stations.

Potential radiological air particulate effluents are generated primarily from dried uranium concentrate in the yellowcake drying and processing areas. Following precipitation, the uranium concentrate is fed to a gravity thickener. The gravity-thickened yellowcake solids solution will be pumped into a plate and frame filter press for dewatering from which the product is only at an approximately 60 percent solids content. Dewatered yellowcake drops from the filter press into a live bottom hopper with a screw auger to move the pressed yellowcake slurry to a sump where a progressing-cavity positive displacement pump transfers the yellowcake to the dryers. Although minor spills can occur during the thickening and dewatering process, they will be cleaned up quickly and subsequently surveyed to minimize any potential airborne source.

4.1.2.1 Yellowcake Drying and Packaging

The yellowcake drying and packaging area at the Dewey-Burdock ISL facility will be serviced by a dedicated ventilation system. By design, vacuum dryers do not discharge uranium for the following reasons. The vacuum drying system is proven technology, which is being used successfully at several facilities where uranium oxide is being produced, including ISL facilities (NMA 2007). The off gas treatment system of the vacuum dryers includes a baghouse, condenser, vacuum pump, and packaging hood. The potential radionuclide particulate releases from the drying process and associated off gas treatment system are discussed below.

The yellowcake will be dried at approximately 250 degrees Fahrenheit (°F) in the rotary vacuum drying process. The off gases generated during the drying cycle are filtered through a baghouse, which is located on the top of the dryer, to remove particles down to approximately 1 micron in size. The gases are then cooled and scrubbed in a surface condenser to further remove the smaller size fraction particulates and the water vapor during the drying process. Two rotary vacuum dryers will be located in a separate building attached to the CPP. This attached building will contain the dryers, the baghouses on the dryers, and a condenser scrubber and vacuum pump system for each dryer. The dryers will be heated with a heat transfer fluid (HTF) that circulates through the shell and the rotating central shaft. The heat transfer fluid will be heated by two natural gas or propane-fired HTF heaters, each provided with HTF pumps for circulating the HTF through the shell and central shaft of the dryer. The HTF heaters and pumps will be in a separate structure attached to the back of the dryer building. The water-sealed vacuum pumps will provide the vacuum source while the dryer is being loaded and while the yellowcake is unloaded into drums.

The vacuum dryers are steel vessels heated externally as described above and fitted with rotating plows to stir the yellowcake. The chamber will have a top port for loading the wet yellowcake and a bottom port for unloading the dry powder. A third port will be provided for venting through the baghouse during the drying procedure. The baghouse and vapor filtration unit will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The baghouse will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system.

The condenser will be located downstream of the baghouse and will be water cooled. It will be used to remove the water vapor from the non-condensable gases emanating from the drying chamber. The gases are moved through the condenser by the vacuum system. Dust passing through the bag filters is wetted and entrained in the condensing moisture within this unit. The vacuum pump will be rotary water sealed providing negative pressure on the entire system during the drying cycle. It will also be used to provide negative pressure during transfer of the dry powder from the drying chamber to 55-gallon steel drums. The water seal of the rotary vacuum pump captures entrained particulate matter remaining in the gas streams.

The packaging system will be operated on a batch basis. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a bottom port into 55-gallon steel drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture will be provided by a sealed hood that fits on the top of the drum, which will be vented through a sock filter to the condenser and the vacuum pump system when the powder is being transferred.

4.1.2.2 Atmospheric Discharges from the Yellowcake Drying and Packaging System

There are three discharge locations associated with the yellowcake drying and packaging system. These include: i) the yellowcake discharge valve located directly below the dryer, through which drums are filled with yellowcake, ii) the condensed water vapor that is removed from the condenser and recycled to the yellowcake thickener, and iii) very small amounts of air that are drawn through the vacuum pump and are exhausted into the dryer room of the CPP. The system of treating gases emanating from the dryer chamber with bag house filters and water condenser is designed to capture virtually all particles from the vapor stream leaving the dryer (NUREG-

1910, pg. 2-25). Furthermore, NUREG-1569, Section 7.3.1.2.2 states, "When a vacuum dryer is used for yellowcake, then dust emissions from drying may also be assumed to be negligible."

Points of discharge will be routinely monitored via filter collection and radiochemical analysis for Natural U, Th 230, Ra 226 and Pb 210 to ensure radionuclide effluent releases are maintained ALARA. The water that is collected from the condenser will be recycled to the precipitation circuit, eluant makeup, or disposed with other process water. General plant air will be monitored routinely for airborne radionuclides.

The system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures. The system will alarm if there is an indication that the emission control system is not performing within operating specifications. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition, and the dryer will not be unloaded or reloaded until the emission control system is returned to normal service.

To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signal an audible alarm at the dryer and in the CPP control room if the air pressure (i.e. vacuum level) falls below the specified threshold. The operation of this system is routinely monitored during dryer operations. The operator will perform a manual check of the vacuum alarm before each packaging event and document inspections of the vacuum level hourly or more frequently during dryer operations. Additionally, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

4.1.3 Other Airborne Emissions

Other emissions to the air are possible from limited vehicular traffic (exhaust and dust). Potential impacts from potential emissions from process chemicals that will be used at the plant are described in Section 7.5. There will not be any significant combustion related emissions from the process facility as commercial electrical power is available to the site.

4.1.4 Accident Scenarios

The accident scenarios with potential to occur at the facility are those typical of other ISR facilities. These scenarios have been evaluated in NUREG/CR-6733, A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees (NRC, 2001) and are discussed below. Three primary engineering controls that will exist at the site include 1) downflow pressurized IX columns, 2) building ventilation, and 3) use of a modern vacuum yellowcake dryer. Also included in the engineering controls will be alarms to indicate suboptimal operating conditions of the effluent control systems and concrete curbs and sumps to contain any process spills. Administrative controls such as training for emergency scenarios will be in place to provide appropriate worker protection in the event the effluent control systems fail under an emergency situation. In brief, the engineering controls coupled with appropriate administrative controls will mitigate any potential health and safety impacts of system failures at the facility.

NRC has evaluated likely accident scenarios and the associated radiological consequences for a typical ISR facility. This analysis is contained in NUREG/CR-6733. A series of potential accident scenarios which could occur in the CPP or Satellite Facility area were evaluated and included the following:

- Yellowcake thickener failure and spill
- Radon release in enclosed process areas
- Pregnant lixiviant and loaded resin spills
- Yellowcake dryer hazard analysis

The estimated radiological consequence resulting from these accidents ranged from no significant radiological exposures, in the case of the thickener failure and pregnant lixiviant/loaded resin spill, to a significant radiological exposure which could result in doses to workers exceeding those allowed in 10 CFR Part 20. Due to the short term nature of the above scenarios and assuming spills and releases are mitigated promptly, no scenario was expected to result in a significant estimated radiological dose to members of the public.

Given the accident scenarios described above, if effluent controls are operable during and while responding to the accident, they will reduce the potential radiological consequence to the workers involved in the response by reducing airborne radionuclide concentrations. If the

effluent controls are not operable because of the accident, this reduction in airborne radionuclide concentrations would not occur and administrative controls and personal protective equipment would play a larger role in minimizing worker doses.

During an accident, administrative controls will be in place such as standard operating procedures for spill response and cleanup, programs for radiation and occupational monitoring, and training for workers in radiological health and emergency response. Administrative controls coupled with proper use of personal protective equipment (PPE) such as respirators are the best tools to reduce worker doses and will be provided.

Other approaches to mitigate system failures that may result in exceeding exposure limits include but are not necessarily limited to the following:

1) A team of responders, trained for radiation health and emergency response, will be available. Specific training will include: response monitoring, PPE use and response to fires, large lixiviant spills or ion-exchange system failure.
2) Powertech (USA) will train local emergency response personnel in the potential hazards present within the project area.
3) A yellowcake thickener failure and spill will result in the immediate evacuation of normal operating personnel within the spill area and cleanup of the saturated product prior to drying. Employees performing the cleanup will utilize the appropriate PPE to minimize exposure to any product that may dry during cleanup. Yellowcake residue that may remain within the thickener area will be washed into a sump, thus mitigating the potential for exposure to employees.
4) Radon release into an enclosed area will result in an immediate evacuation within the release area of normal operating personnel, manual shutdown of the release point (if automated shutoff system failed) and promotion of ventilation within the area manually (if automated ventilation system failed). Employees performing manual shutdown within the area of the release will utilize the appropriate PPE (such as atmosphere-supplying respirators designed to protect against gases) to minimize exposure to radon and radon decay products. Radon samples will be taken and if above normal working levels, workers will remain evacuated and only return to normal duties within the release area upon re-establishment of normal working levels.
5) A pregnant lixiviant spill will be mitigated in a manner consistent with the location and degree of spill. Normal operating employees within the spill area will be evacuated. Response personnel will utilize the appropriate PPE to protect against radon and radon decay products exposure as discussed above and cleanup will result.
6) A yellowcake dryer upset response would be dictated by the severity of the upset.

Mitigation response may include a combination of additional site-specific response actions such as:

- Workers, including the spill response team, will have access to respiratory equipment in the yellowcake dryer area.
- All practicable measures will be taken to control emissions at the source. The operator will reduce exposure to airborne effluent releases by implementing emission controls (such as wetting) and institutional controls (such as extending the area of upset so as to exclude any personnel not responding to the upset).
- Siting of the CPP near the center of the proposed license area will serve to protect against off-site exposures in the event of a yellowcake dryer upset.
- Individual dose standards will be strictly implemented to assure exposures are limited and reduced to the maximum extent reasonably achievable and to limit contamination to the designated upset area.
- All drying and packaging operations will terminate until cleanup is complete, the area has been cleared for potential exposure, and equipment has been restored to proper operating conditions and efficiencies.
- Cessations, corrective actions and restarts will be reported to the NRC within 10 days of the upset or off-normal performance.

4.2 Liquid Waste

4.2.1 Sources of Liquid Waste

Several sources of liquid waste are collected as a result of ISL production:

- Storm water runoff
- Waste petroleum products and chemicals
- Domestic sewage and
- Three types of byproduct materials

According to the latest interpretation concerning 11e.(2) defined in Chapter 2, Section 11 of the AEA of 1954, more fluid type wastes are associated in order to provide regulation within the ISL industry (NUREG-1575, 2000). Three types of liquid waste fall within the confines of the 11e.(2) definition:

- Liquid process wastes, such as production bleed, resin transfer water and brine generated from the elution and precipitation circuits;
- Groundwater generated during aquifer restoration; and
- Affected groundwater generated during well development.

The following sections presents potential liquid waste sources and effluent controls to be utilized during process operations at the Dewey-Burdock project.

4.2.1.1 Liquid Process Waste

The primary source of liquid waste, as previously discussed in Section 3.0, is the operation of the IX process which generates production bleed. Other sources of liquid waste from the CPP include laboratory chemicals, laundry water, plant wash down water and the waste brine streams from the elution and precipitation circuits; however, these liquid waste streams make up a much smaller portion of the total liquid waste stream at the Dewey-Burdock facility. Liquid process waste will either be sent to a deep disposal well or will be treated with barium chloride and then used for land application within the project area using center-pivot sprinklers (refer to Section 4.2.2).

4.2.1.2 Aquifer Restoration

During aquifer restoration, the technology selected will depend on the liquid waste disposal option. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. Additional information about aquifer restoration methods is provided in Section 6.1.3.

4.2.1.3 Water Collected from Well Field Development

During well development or redevelopment, water will be collected, treated and the waste will be disposed of via a deep disposal well or treatment and land application. Water from injection

lixiviant or recovery fluids recovered from areas where a liquid release has occurred from a pipeline or well will be placed into the wastewater disposal system for either deep well disposal or treatment and land application.

4.2.1.4 Storm Water Runoff

Another source of liquid waste is stormwater runoff. DENR is responsible for administering the stormwater management program that is closely modeled after the federal National Pollutant Discharge Elimination System (NPDES) program. Facility drainage will be designed to route stormwater runoff either away from or around the plant, ancillary buildings and parking areas, and chemical storage. The design of the project facilities, combined with engineering and procedural controls contained in a Best Management Practices (BMP) Plan, will ensure that stormwater runoff is not a potential source of pollution.

4.2.2 Liquid Waste Disposal

Powertech (USA) proposes two options for liquid waste disposal at the Dewey-Burdock Project. Liquid waste includes the production bleed, groundwater generated during aquifer restoration, process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), affected well development water, laboratory wastewater, laundry water, and plant wash down water. The preferred disposal option is underground injection of treated liquid waste in non-hazardous Class V deep disposal wells (DDWs). In this disposal option liquid waste will be treated to satisfy EPA non-hazardous waste requirements and injected into the Minnelusa and/or Deadwood Formations in four to eight DDWs being permitted pursuant to the SDWA through the EPA UIC Program. Further details about the proposed DDW liquid waste disposal option are presented below, including information about the pending UIC permit. Powertech (USA) will provide updated information regarding its Class V application when appropriate milestones are reached. It is anticipated that all liquid waste will be disposed using this option if sufficient capacity is available in DDWs.

The alternate liquid waste disposal option is land application. This option involves treatment in lined settling ponds followed by seasonal application of treated liquid waste through center pivot sprinklers. Land application, if used, will be carried out under a Groundwater Discharge Plan

(GDP) permit through the SD DENR. Depending on the availability and capacity of DDWs, Powertech (USA) may use land application in conjunction with DDWs or by itself. Additional details about the design and permitting status of the land application system are provided below.

4.2.2.1 Land Application

Land application, if used, will be carried out under a GDP permit through SD DENR. A copy of the SD DENR application to permit land application of treated liquid waste has been provided to NRC (see ML12089A360). The land application system will consist of irrigation center pivots, associated pumps and piping, radium settling ponds, and outlet and storage ponds.

Two general land application areas are proposed for liquid waste disposal within the project area, one near the Dewey Satellite Facility and one near the Burdock CPP. Each land application area is anticipated to have 315 acres of irrigated area consisting of individual 50-, 25-, and 15-acre center pivots. In addition each site also will have approximately 65 acres of center pivots on standby, which can be used during repairs and maintenance of other center pivots or used on a rotating basis. The total land application area at the project will be 760 acres, with only 630 acres needed for design flow rates. Center pivot irrigation systems will typically operate 24 hours per day during the growing season, which is approximately April through October. During winter months, when land application will not be used, the treated liquid waste stream will be temporarily stored in storage ponds, which will be located near both the Dewey and Burdock processing facilities. Section 3.1.6.1 contains more specific information concerning pond sizes and functions.

Disposal capacity for the land application system was estimated using the SPAW (Soil-Plant-Atmosphere-Water) model, which is described below. In addition to estimating the water budget for agricultural landscapes, the SPAW model also was used to estimate the water budget for impoundments.

In the land application option, groundwater withdrawn during aquifer restoration will not be treated with RO. Instead, the aquifer restoration water will be disposed directly in land application systems following treatment to remove uranium and radium. The typical liquid waste flows using the land application option are 47 gpm during uranium recovery without concurrent restoration, 547 gpm during concurrent uranium recovery and aquifer restoration, and about 500 gpm during aquifer restoration only.

In the land application option, pumping will occur 24 hours a day. The estimated daily water budgets obtained from SPAW modeling indicate that each land application area will be capable of disposing approximately 297 gpm from March 29 to May 10, about 653 gpm from May 11 to September 24, and approximately 297 gpm from September 25 to October 31. Normally there will not be land application disposal from approximately October 31 to March 29. Detailed information regarding the SPAW model inputs and outputs are discussed in Appendix D to the Pond Design Report, which is provided as Appendix 3.1-A.

The land application system will be capable of handling all of the expected liquid waste throughout each phase of the project. During the winter months liquid waste will be stored in ponds, which are described in more detail in Sections 3.1.6.1. The capacity required to store the liquid waste throughout the winter months was calculated using the SPAW model to be approximately 216 acre-feet. By comparison, the total storage pond capacity under the land application option will be approximately 510 acre-feet, not including spare storage ponds. The combined capacity of both areas will be more than sufficient to dispose of the liquid waste stream during the spring, summer, and fall months. In addition, adequate excess capacity will be present during these months to dispose of stored surplus liquid waste from the winter months. Figure 3.1-1 depicts the proposed facilities in the land application option. The water balance for the land application option is presented in Section 4.2.2.4. Water treatment is discussed in Section 3.1.6.4.

4.2.2.1.1 SPAW Model Description

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

processes such as runoff, infiltration, evapotranspiration, soil water profiles, and percolation. Water volumes for each component of the water balance are estimated by multiplying the water budget depth times the associated field area.

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

4.2.2.1.2 Model Input Parameters

4.2.2.1.2.1 Meteorological Parameters

The local climate at the project site is continental, with hot summers, cold winters, and an average annual precipitation of 16.4 inches. The wettest months are from April to September. May and June are the months of highest average precipitation, with occasional thunderstorms that can be severe. Typical daytime temperatures range from 35 degrees Fahrenheit (^{o}F) in January to 85 ^{o}F in July, with nighttime temperatures dropping by approximately 15 to 30 ^{o}F.

Because of limited on-site climatic data, twenty-eight years of daily precipitation and temperature values (from 1980 to 2007) from the nearest available meteorological station at Edgemont, South Dakota were downloaded from the National Climatic Data Center and used as input data for the SPAW Model. The Edgemont station is approximately 13 miles southeast of the site at an elevation of 3460 feet above mean sea level (amsl). The project plant site is at 3720 feet amsl. Table 4.2-1 shows the average monthly air temperature data at the Edgemont station for the 28-year period of record.

Table 4.2-1: Average Monthly and Annual Air Temperature at Edgemont, SD Station (°F)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
22.6	26.8	36.6	46.7	56.9	66.4	74.3	72.5	61.3	47.8	33.0	22.6	47.3

4.2.2.1.2.1.1 Precipitation

Daily precipitation values for the 28-year period of record from the Edgemont station were used as input data for the SPAW Model. Where daily data were absent in the record, the daily average for that month from the 28-yr record was used. No adjustments were made to the precipitation values for the 260-foot elevation difference between the Edgemont station and the project site. Table 4.2-2 shows the average monthly precipitation at the Edgemont station for the 28-yr period of record.

Table 4.2-2: Average Monthly and Annual Precipitation at Edgemont, SD Station (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.33	0.50	1.09	1.87	2.48	2.60	2.17	1.59	1.38	1.31	0.69	0.43	16.44

4.2.2.1.2.1.2 Potential Evapotranspiration

The SPAW model requires daily potential evapotranspiration (PET) data. Lake evaporation is a close estimate of PET, and is similar to PET values estimated using the Penman method. The mean annual lake evaporation (PET equivalent) at the site was determined to be 44 inches using the Evaporation Atlas for the Contiguous 48 United States (Farnsworth and Thompson, 1982). The monthly PET was calculated by applying the values for the monthly distribution of evaporation for the north central United States that are contained in the SPAW model. The daily PET for each month was then calculated by dividing the monthly PET by the number of days in the month. Table 4.2-3 shows the estimated average monthly and annual potential evapotranspiration at the site that was calculated using this method.

Table 4.2-3: Average Monthly and Annual Potential Evapotranspiration at Project Site (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.92	1.23	1.98	3.30	4.40	5.76	7.08	6.95	5.50	3.74	2.02	1.10	44.0

4.2.2.1.2.2 Material Properties

To characterize the soils at the site, eleven test pits were excavated on July 11 and 12, 2008. Samples were collected at various depths and analyzed for particle size distribution, dry bulk density, permeability, and other geotechnical parameters. Test pits 1 through 5 were excavated

at the Dewey land application area, and test pits 6 through 11 were excavated at the Burdock land application area. The test pit locations are shown on Plate 2.5-1. Table 4.2-4 shows the USDA soil texture and dry bulk density for the test pit samples. These are the parameters that are used as input to the SPAW model.

Natural Resources Conservation Service (NRCS) soil survey maps for the PAA were downloaded from the NRCS Web Soil Survey. The particle size distributions for the NRCS soil mapping units were compared to the laboratory particle size distributions for the test pit soil samples. This comparison showed that the laboratory results for the test pit samples generally fell within the range of particle size distributions for the NRCS survey soil mapping units.

Table 4.2-4: Summary of Test Pit Soil Properties USDA Soil Texture Class and Dry Bulk Densities

Sample No.	Depth	Gravel	Sand	Silt	Clay	Dry Bulk Density
Units:	(ft)	% by wt	% by wt	% by wt	% by wt	(lb/ft^3)
TP01-1	1	0.20	26.20	38.00	35.60	N/A
TP01-3	3	0.10	25.70	27.20	47.00	101.20
TP01-7	7	0.90	8.10	57.20	33.80	86.30
TP02-1	1	0.00	19.90	40.70	39.40	94.50
TP02-4	4	0.00	16.70	34.60	48.70	101.50
TP02-7	7	0.20	26.70	34.80	38.30	92.50
TP03-1	1	0.00	24.30	24.80	50.90	90.00
TP03-7	7	0.00	2.40	25.10	72.50	104.60
TP03-11	11	60.00	25.00	8.90	6.10	
TP04-1	1	2.20	47.80	18.20	31.80	98.10
TP04-7	7	1.30	27.50	28.00	43.20	113.30
TP05-1	1	1.50	24.00	31.60	42.90	97.00
TP05-4	4	2.00	30.00	23.40	44.60	94.80
TP05-8	8	0.80	22.10	57.60	19.50	106.30
TP06-1	1	0.30	17.90	30.80	51.00	N/A
TP06-7	7	0.00	42.00	31.80	26.20	N/A
TP06-10	10	0.00	40.00	31.20	28.80	N/A
TP07-1	1	0.60	17.40	27.30	54.70	105.30
TP07-5	5	0.1	22.1	25.9	51.9	103.90
TP07-10	10	0.3	19.7	6.9	73.1	105.40
TP08-2	2	0.1	11.9	35.7	52.3	95.20
TP08-6	6	0.4	56.6	25.4	17.6	103.40
TP09-1	1	0.3	15.2	39	45.5	94.90
TP09-4	4	0.1	35.9	37.8	26.2	109.60
TP10-1	1	1.8	21.1	34.8	42.3	99.10
TP10-7	7	0.4	11.1	30.3	58.2	105.80

Notes: N/A = Results for these samples were not available.

In addition to soil data from test pits, soil samples were obtained from 37 auger holes of which 18 were at the Dewey site and 19 were at the Burdock site located as shown on Plate 2.5-1. Soil samples were collected by BKS at various depths and analyzed for selected physical/chemical characteristics including saturated paste extracts for electrical conductivity (EC), pH, Ca, Mg, Na, Cl, SO_4, HCO_3, As, Ba, Cd, Cr, Pb, Hg, Se, and Ag. USDA percent sand, silt and clay, as well as organic matter, natural moisture content, and saturation moisture content also were determined. Table 4.2-5 summarizes average values at each site for EC, pH, organic matter, Ca, Mg, Na, sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), residual sodium carbonate (RSC), USDA soil texture, and as concentrations for the upper soil layer (0 to 11 inches below ground surface) and the deeper soil layer (approximately 50 inches below ground surface) for the auger samples. These are the parameters that are used to assess the success of growing alfalfa using the treated process water.

Analysis of Table 4.2-5 indicates that the existing soils to be irrigated at both the Dewey and Burdock sites indicates that the existing soils are fine grained; comprised of primarily clay, clay loam, and silty clay textures. Particularly at Dewey, the sodicity of the soils, as reflected by SAR, could be a source of concern if these soils are irrigated. At both the Dewey and Burdock sites the physical/chemical constituents increase with soil depth and are typically high values below the top one-foot of soil, as would be expected in these fine-grained soils of marine sediment parent material.

The two potential issues associated with long-term application of treated process water to the Dewey and Burdock sites are changes in the physical properties of the soils (lower hydraulic conductivity and crusting) and changes to the chemical properties of the soils (increased salts and trace metals). These potential changes will be closely monitored.

Table 4.2-5: Summary of Dewey and Burdock Soil Physical/Chemical Characteristics in Land Application Areas[7]

Area	Depth	EC	pH	Organic Matter	Ca	Mg	Na	SAR	ESP[6]	USDA	As
	(in)	(mS/cm)	(std. units)	(%)	(meq/L)	(meq/L)	(meq/L)	(unitless)	(unitless)	Texture	(mg/kg)
Dewey[1]	0 - 11	1.22	6.8	1.6	4.4	2.8	6.3	3.19	3.33	C-CL-SiCL	16.8
	≈50	5.40	6.8	0.5	16.9	27.0	33.0	7.39	8.79	SiC-CL-C-SL	13.1
Dewey[3]	84	--[5]	--[5]	1.3	100.4	50.2	78.6	10.90	12.91	C	--[5]
Burdock[2]	0 - 11	1.64	7.3	1.8	8.2	4.1	5.3	1.91	1.53	C-CL-SiC	9.6
	≈50	5.98	7.7	0.7	24.5	34.7	37.5	6.16	7.26	C-CL-SiC-L	9.4
Burdock[4]	84	--[5]	--[5]	1.1	100.6	84.9	28.3	4.80	5.50	CL	--[5]

(1) Average of 18 values from auger cores. BKS Environmental Associates, Inc. (Oct. 7, 2008).
(2) Average of 19 values from auger cores. BKS Environmental Associates, Inc. (Oct. 7, 2008)
(3) Average of 3 values from test pits. Knight Piésold and Co. (2008)
(4) Average of 2 values from test pits. Knight Piésold and Co. (2008)
(5) -- means no data available.
(6) Calculated from average SAR.
(7) See Plate 2.5-1 for locations of auger cores, test pits, and irrigated areas.

4.2.2.1.2.3 Irrigation Water Properties

During land application, there could be potential impacts to the soil and crops from total dissolved solids (TDS) and electrical conductivity (EC) values in the water to be used to irrigate alfalfa or other crops as shown in Table 4.2-6. Pursuant to applicable standards, irrigation water quality is commonly assessed in terms of soluble salt content, percentage of sodium, boron, and bicarbonate contents. In the case of the water used for irrigation the soluble salts are on the order of 3,000 to 4,000 μS/cm at 25 ^{o}C. These levels pose low to moderate risk to the growth of moderately sensitive crops such as alfalfa and corn. The SAR levels are low and pose little risk to water erosion during the infiltration of rain or snowmelt. There could be some salt deposition at the surface, however maintaining maximum vegetative cover will reduce the possibility of undesirable species. During the irrigation season, water application rates will be adjusted to optimize both evaporation and crop production.

Table 4.2-6: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Production Ground Water Quality Assuming High Chloride Concentrations[4]

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

(1) ESP = Exchangeable Sodium Percentage. Empirical relationship from Withers and Vipond (1980).

$$ESP = \frac{100(-0.0126 + 0.01475 * SAR)}{1 + (-0.0126 + 0.01475 * SAR)}$$

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

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

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

Table 4.2-7 provides the estimated water quality to be applied to crops at both the Dewey and Burdock land application sites. It is anticipated that trace metal concentrations will be at or below EPA Primary Drinking Water Standards. In addition, the effluent concentration limits for the release of radionuclides to the environment as contained in 10 CFR Part 20, Appendix B will be met.

Table 4.2-7: Estimated Land Application Water Quality

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

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

4.2.2.1.3 Modeling Approach

The general assumptions for the SPAW model include the following:

1. The model is a one-dimensional vertical model.
2. The model assumes that the modeled area is spatially uniform in soil, crop and climate characteristics.
3. Model inputs and outputs are based on daily values.
4. The model does not does not include flow routing or channel descriptors.
5. Daily runoff is estimated as an equivalent depth over the simulation field by the USDA/SCS Curve Number method.
6. The field budget utilizes a one-dimensional vertical system beginning above the plant canopy and proceeding downward through the soil profile to a depth sufficient to represent the complete root penetration and subsurface hydrologic processes (lateral soil water flow is not simulated).

Specific assumptions related to this project are as follows:

7. Daily precipitation and temperature data used in the model are based on 28 years of record from the Edgemont, South Dakota station.
8. SPAW modeling was done for two land application and pond areas, the Dewey site and the Burdock site.
9. Soils data used in the modeling of the Dewey site was based on a composite of soils data from Test Pits 1, 2 and 5.
10. Soils data used in the modeling of the Burdock site was based on a composite of soils data from Test Pits 8, 9 and 10.
11. The 24/7 year-round inflow rate from process water and bleed water at each site is 310 gpm.
12. The irrigation season is from March 29 to October 31 each year (217 days).
13. Model runs were conducted assuming no crop (bare soil). This assumption ensures that the results will be conservative in terms of the resulting evapotranspiration and runoff, since it is difficult to model the response to alfalfa or other crops to the quality of the applied irrigation water and to the soil conditions present at the site.
14. The irrigation water will be applied at a rate that balances the total amount of process inflow water. The modeled application rate is 297 gpm from March 29 to May 10, 653 gpm from May 11 to September 24, and 297 gpm from September 25 to October 31.

15. Irrigation tailwater and runoff from the land application areas will be conveyed to collection areas at the edges of the land application areas and allowed to evaporate and seep into the soil.
16. The storage impoundments are designed to contain the one percent exceedance probability event (100-year event) plus 3 feet of freeboard.
17. All storage impoundments have side slopes of 3 to 1 and are 30 feet deep.

The objective of the SPAW modeling was to help design a land application system that: (1) maximizes evapotranspiration; (2) minimizes surface runoff; (3) minimizes percolation below the rooting zone; (4) minimizes the irrigated acreage required; and (5) minimizes the required volume of the storage ponds while maintaining a one percent probability that the design pond volume will be exceeded during the operating life of the facility.

SPAW modeling was performed at both the Dewey and Burdock sites. A composite of the soil properties at each site was created for use in the model using analytical data from three test pits from each site. Test pits 1, 2 and 5 were used for the Dewey site and test pits 8, 9 and 10 were used for the Burdock site. The composites were created by taking the averages of the gravel, sand and clay fractions and the dry bulk densities for each depth interval for the three test pits at each site.

The SPAW modeling assumed that the facility will operate on a year-round basis for 15 years. Twenty-eight years of daily precipitation, temperature and evaporation data from January 1, 1980 to December 31, 2007 were used to create 28 unique and equally likely simulations of the process water balance. Each simulation used 15 years of sequential climatic data corresponding to the 15 years of operation of the facility. The climatic data intervals used for each of the 28 simulations are shown in Table 4.2-8.

Field simulations using the SPAW model were run using each of the 28 climatic data intervals shown in Table 4.2-8. The results of these field simulations were used as the input to pond simulations for the same 28 climatic intervals. The result was a daily pond volume for each day of the year for each of the 28 15-year simulations.

The pond volume with a 1 percent exceedance probability during a 15-year operating period was estimated as follows. First, the average pond volume for each day during the 15-year operating period for the 28 simulations was calculated. Then, the pond volume for each day of the 15-year period with a 1 percent exceedance probability was calculated using the Grumbel Extreme Value distribution, which resulted in 5,475 possible values. The greatest of these 5,475 values was then selected as the maximum possible volume with a 1 percent exceedance probability during a 15-year period.

Table 4.2-8: Sequential Water Balance Simulations

Simulation No.	15-Year Climatic Data Interval
1	01/01/1980 to 12/31/1994
2	01/01/1981 to 12/31/1995
3	01/01/1982 to 12/31/1996
4	01/01/1983 to 12/31/1997
5	01/01/1984 to 12/31/1998
6	01/01/1985 to 12/31/1999
7	01/01/1986 to 12/31/2000
8	01/01/1987 to 12/31/2001
9	01/01/1988 to 12/31/2002
10	01/01/1989 to 12/31/2003
11	01/01/1990 to 12/31/2004
12	01/01/1991 to 12/31/2005
13	01/01/1992 to 12/31/2006
14	01/01/1993 to 12/31/2007
15	01/01/1994 to 12/31/1980
16	01/01/1995 to 12/31/1981
17	01/01/1996 to 12/31/1982
18	01/01/1997 to 12/31/1983
19	01/01/1998 to 12/31/1984
20	01/01/1999 to 12/31/1985
21	01/01/2000 to 12/31/1986
22	01/01/2001 to 12/31/1987
23	01/01/2002 to 12/31/1988
24	01/01/2003 to 12/31/1989
25	01/01/2004 to 12/31/1990
26	01/01/2005 to 12/31/1991
27	01/01/2006 to 12/31/1992
28	01/01/2007 to 12/31/1993

4.2.2.1.4 Model Results

Field Model Results

Based on the SPAW modeling, the total irrigated area at the Dewey site would be 315 acres. In addition, there would be 65 acres on standby. Pumping at Dewey would occur for 24 hours every day from March 29 to May 10 at a rate of 297 gpm; from May 11 to September 24 at a rate of 653 gpm; and from September 25 to October 31 at a rate of 297 gpm.

The irrigated area at the Burdock site would also be 315 acres, with an additional 65 acres on standby. Pumping at Burdock would also occur for 24 hours every day from March 29 to May 10 at a rate of 297 gpm; from May 11 to September 24 at a rate of 653 gpm; and from September 25 to October 31 at a rate of 297 gpm.

The annual summaries of the SPAW field modeling results for the twenty-eight 15-year simulations at both the Dewey and Burdock sites are shown in Appendix D of Appendix 3.1-A. The center pivot areas at both the Dewey and Burdock sites are shown on Figure 3.1-1.

Pond Model Results

Based on the assumptions listed above (Section 4.2.2.1.3), the model results showed that the total irrigation storage pond volume having a 1-percent exceedance probability is 216 acre-feet at both the Dewey and Burdock sites. An additional 31 acre-feet of capacity was added to the ponds at each site, for a total pond capacity of 247 acre-feet. This additional capacity acts as contingency storage for days at the beginning of the irrigation season when weather conditions may limit pumping for land application. Four single-lined impoundments (ponds), each with dimensions of 465 feet x 465 x 30 feet deep and a capacity of 61.8 acre-feet, will be operational at any given time at both the Dewey and Burdock sites, providing a total capacity of 247.2 acre-feet at each site. This capacity includes the volume with a 1 percent exceedance probability, plus 3 feet of freeboard. A double-lined radium settling pond with leak detection will also be constructed at each site, with an operational storage of 39.2 acre-ft, which includes sufficient capacity for the settling of barium sulfate and radium, the total volume of which over the 15-year operating life is estimated to be 0.036 acre-feet. In addition, there will be a Central Plant Pond at the Burdock site. The CPP pond will be 362 feet x 362 feet x 25 feet deep including 3 feet of freeboard, with a total capacity of 36.2 acre-feet.

The annual summaries of the SPAW pond modeling results for the twenty-eight 15-year simulations at the Burdock site are provided in Appendix D of Appendix 3.1-A. The climatic conditions and pond inflow rates are the same for both sites, and therefore the SPAW pond modeling results are also the same.

4.2.2.1.5 Land Application Monitoring

The land application system will be permitted through SD DENR under a Groundwater Discharge Plan permit. The system will be monitored in accordance with SD DENR requirements for potential environmental effects and to track system performance. A general summary of system monitoring is described in the following section. A detailed description of the system monitoring plan is contained in Section 6 of the Groundwater Discharge Plan permit application. The following types of samples will be collected for laboratory analysis:

- Supplemental freshwater (if needed)
- Land applied process water
- Air
- Soil
- Biomass
- Surface Water
- Groundwater

The parameters for analysis of each sample type (water, soils, vegetation and air) will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7.

4.2.2.1.5.1 Supplemental Freshwater

In the event that supplemental freshwater from the Madison aquifer or another suitable formation is used to supplement the water from the storage ponds for land application, grab samples of this supplemental freshwater will be collected in accordance with SD DENR requirements during times of use. The parameters for analysis will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7.

Samples will be collected in accordance with SD DENR requirements.

4.2.2.1.5.2 Land Applied Process Water

Grab samples of land applied process water will be collected in accordance with SD DENR requirements from a point in the distribution system downstream from the storage ponds. The parameters for analysis will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7.

4.2.2.1.5.3 Air

Locations of air monitoring stations are shown in Figure 5.7-10. The filters from air samplers operating continuously will be analyzed for at least two quarters prior to the beginning of operations, and then quarterly for the parameters provided in RG 4.14. The samplers will have sensors to measure total air flow within a sampling period. Passive track-etch detectors will be deployed at each station for monitoring radon-222 on a quarterly basis.

4.2.2.1.5.4 Soil

Soil samples will be collected from within each pivot area prior to the beginning of operations and at the end of each irrigation season after operations begin in accordance with SD DENR requirements. The parameters for analysis will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7. Suction lysimeters will be placed in each of the center pivot circles at both the Dewey and Burdock sites to obtain pore water samples for the physical/chemical analyses provided in RG 4.14 and selected parameters listed in Table 4.2-7. Lysimeter depths will be coordinated with SD DENR.

Pore water samples and measurements of soil moisture will be done in accordance with SD DENR requirements. Supplemental measures of hydraulic conductivity may be done if it appears to change during the operation of the irrigation systems.

4.2.2.1.5.5 Biomass

Samples of the crops or vegetation grown on the land application areas at Dewey and at Burdock will be collected at the end of each irrigation season during operations. The number of samples will be coordinated with SD DENR. Samples of livestock that have been fed crops grown on the land application pivot areas at the PAA during operations will be collected once per year, shortly after slaughter. The samples of vegetation and livestock will be analyzed for the parameters provided in RG 4.14.

4.2.2.1.5.6 Surface Water

Surface water samples will be collected at operational monitoring points shown on Plate 5.7-1. Samples will be collected quarterly at each of the monitoring stations and analyzed for the parameters provided in RG 4.14 and selected parameters listed in Table 4.2-7.

4.2.2.1.5.7 Groundwater

Groundwater samples will be collected quarterly from a monitoring network established according to SD DENR requirements. These samples will be analyzed for the parameters provided in RG 4.14 and selected parameters listed in Table 4.2-7.

All sampling activities will be conducted in accordance with an approved quality assurance/quality control plan. Records of all sampling activities and laboratory analyses will be maintained and periodic reports of all sampling and analyses will be submitted to the South Dakota Department of Environment and Natural Resources (DENR).

4.2.2.2 Deep Disposal Wells

Powertech (USA) submitted a Class V UIC permit application to EPA Region 8 in March 2010 for authorization to install and operate four to eight DDWs within the project area. A copy of the permit application is provided in Appendix 2.7-L. Additional information is found in Section 3.1.6.3. DDWs will target the Pennsylvanian and Permian-age Minnelusa Formation and the Cambrian-age Deadwood Formation. The targeted injection interval in the Minnelusa Formation ranges from 1,615 to 2,540 feet below ground surface (bgs), and the targeted injection interval in the Deadwood Formation ranges from 3,095 to 3,530 feet bgs.

Powertech (USA) has requested an Area Permit authorizing the installation and operation of four to eight DDWs within the project area. The number of wells required will depend on well capacity. Powertech (USA) has requested authorization to inject up to 300 gpm in a maximum of eight wells. Proposed locations for the first four wells are provided in Figure 3.1-2. The initial four DDWs are proposed at two sites, one near the Dewey Satellite Facility and one near the Burdock CPP. Two disposal wells are proposed at each site with one well targeting the Minnelusa Formation and one targeting the Deadwood Formation. Based on the anticipated porosity, thickness, lateral extent, and permeability of the receiving formations, the capacity of each Class V DDW is expected to range from 50 to 75 gpm.

Prior to Class V DDW disposal, liquid waste will be treated as necessary to comply with non-hazardous Class V UIC requirements (refer to Section 3.1.6.4). Treatment will typically include removal of uranium and other dissolved species in IX columns followed by radium removal through co-precipitation with barium sulfate in radium settling ponds. Surface facilities near the Burdock CPP and Dewey Satellite Facility related to liquid waste disposal in the DDW option will include radium settling ponds, outlet and surge ponds, a Central Plant Pond located at the Burdock CPP, and surface facilities required for DDW operation such as pretreatment facilities, screen/filters, and high pressure pumps for DDWs. Proposed facilities for the deep disposal option are depicted on Figure 3.1-2.

In the DDW option, RO treatment with permeate injection will be the primary method of aquifer restoration. Groundwater withdrawn during aquifer restoration will be treated using RO, and the resulting brine will be treated and disposed with other treated liquid waste in DDWs. As described in Section 4.2.2.4, the total liquid waste flow rate will be approximately 47 gpm during uranium recovery without concurrent restoration, approximately 197 gpm during concurrent uranium recovery and restoration, and approximately 150 gpm during aquifer restoration alone. The planned DDW capacity of up to 300 gpm significantly exceeds the anticipated liquid waste flow rate in the DDW option.

4.2.2.3 Combined Liquid Waste Disposal Option

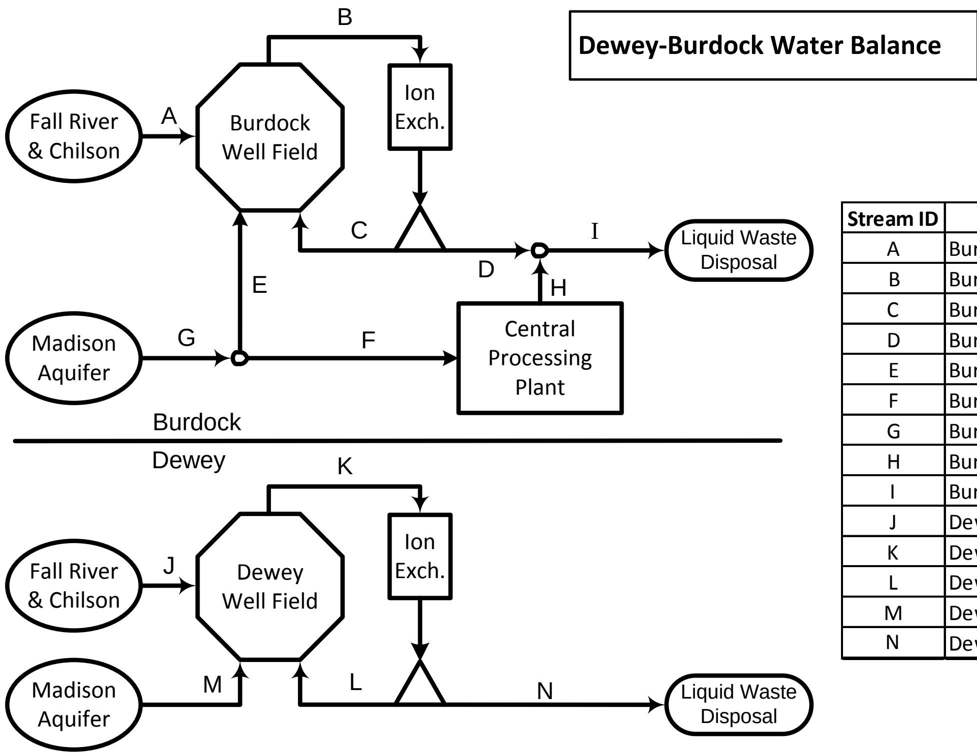
If Class V DDWs are constructed but lack sufficient capacity to dispose of the entire liquid waste stream, Powertech (USA) will combine the use of DDWs and land application. In this option land application facilities will be constructed and used on an as-needed basis depending on the DDW capacity.

4.2.2.4 Water Balance

Typical water balances during uranium recovery and aquifer restoration are presented in Figure 4.2-1. The figure depicts typical flow rates during the uranium recovery and aquifer restoration phases. Table 4.2-10 shows the typical design flow rates during concurrent uranium recovery and aquifer restoration. Detailed descriptions of the water balances for the Dewey-Burdock Project are provided below along with a discussion of liquid waste disposal capacities. The water balances encompass the entire system, including the well fields, Satellite Facility, CPP and liquid waste disposal in accordance with guidance in NUREG-1569, Section 3.1.2.

4.2.2.4.1 Uranium Recovery Water Balance

During uranium recovery, the flow rates will be the same for either liquid waste disposal option. The typical production bleed will be approximately 0.875%. The typical well field production will be approximately 2,400 gpm (Stream B) from Burdock well fields and 1,600 gpm (Stream K) from Dewey wells fields. Note that these are typical flow rates provided to illustrate the water balance when the Dewey and Burdock well fields are operating simultaneously. An important value is the sum of Streams B and K, which represents the typical project-wide production flow rate. This will be approximately 4,000 gpm, which represents the average annual flow rate proposed at full production for the Dewey-Burdock Project. The proportion of the total flow originating in the Dewey and Burdock well fields will vary depending on the well field development sequence. Multiplying the typical production bleed by the typical production flow rates yields typical production bleed flow rates of 21 gpm (Stream A) at Burdock, and 14 gpm (Stream J) at Dewey. Liquid waste from uranium recovery operations at the Dewey area will consist almost entirely of production bleed. At the Burdock area, liquid waste will also include process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), affected well development water, laboratory wastewater, laundry water, and plant wash down water. Liquid waste flow rates, which are represented by Streams I and N, will typically be approximately 33 gpm and 14 gpm, respectively. As described in Section 3.1.6.4, all liquid waste will be treated prior to disposal via deep disposal wells and/or land application.



Stream ID	Description
A	Burdock Aquifer Bleed
B	Burdock Extraction Composite
C	Burdock Reinjection
D	Burdock Well Field Bleed
E	Burdock Madison Make-up
F	Burdock Fresh Brine Make-up
G	Burdock Madison, Total
H	Burdock CPP Brine
I	Burdock Liquid Waste
J	Dewey Aquifer Bleed
K	Dewey Extraction Composite
L	Dewey Reinjection
M	Dewey Madison Make-up
N	Dewey Liquid Waste

Water Balance Flow Rates (gal/min)

Operation phase	Aquifer bleed option	Disposal Option	Burdock Stream ID								
			A	B	C	D	E	F	G	H	I
Recovery	0.875%	DDW	21	2400	2379	21	0	12	12	12	33
		LA	21	2400	2379	21	0	12	12	12	33
Restoration	Without Groundwater Sweep	DDW	2.5	250	175	75	73	0	73	0	75
		LA	2.5	250	0	250	248	0	248	0	250
	With Groundwater Sweep	DDW	42	250	175	75	33	0	33	0	75
		LA	42	250	0	250	208	0	208	0	250

Water Balance Flow Rates (gal/min)

Operation phase	Aquifer bleed option	Disposal Option	Dewey Stream ID				
			J	K	L	M	N
Recovery	0.875%	DDW	14	1600	1586	0	14
		LA	14	1600	1586	0	14
Restoration	Without Groundwater Sweep	DDW	2.5	250	175	73	75
		LA	2.5	250	0	248	250
	With Groundwater Sweep	DDW	42	250	175	33	75
		LA	42	250	0	208	250

Figure 4.2-1: Typical Project-wide Flow Rates during Uranium Recovery and Aquifer Restoration

Table 4.2-10: Typical Project-Wide Flow Rates during Concurrent Uranium Recovery and Aquifer Restoration

Typical Project-wide Flow Rates		Disposal Option			
		Deep Disposal Well		Land Application	
Restoration Option		Without Groundwater Sweep	With Groundwater Sweep	Without Groundwater Sweep	With Groundwater Sweep
Fall River & Chilson	gal/min	40	118	40	118
Madison Formation	gal/min	157	79	507	429
Wastewater Disposal	gal/min	197	197	547	547

4.2.2.4.2 Aquifer Restoration Water Balance

Powertech (USA) proposes two options for disposal of liquid waste at the Dewey-Burdock Project: (1) injection of treated liquid waste in non-hazardous Class V DDWs, and/or (2) land application of treated liquid waste using center pivots. The disposal option selected will determine the method of aquifer restoration used. RO treatment with permeate injection will be used in the DDW option, and groundwater sweep with injection of clean makeup water from the Madison Formation will be used in the land application option. The aquifer restoration methods are described in detail in Section 6.1.3. Both disposal options are included in the water balance to illustrate the different liquid waste disposal flow rates in each option. In the DDW option, the groundwater withdrawn during aquifer restoration will be treated by RO. The concentrated brine solution will be disposed in the DDWs, while the permeate will be reinjected along with Madison Formation makeup water into the well fields. This will reduce the overall flow rate of liquid waste. Flow rates will be higher if land application is used, because the entire restoration stream will be disposed in the land application system.

Although a 1% restoration bleed will be adequate to maintain hydraulic control of well fields undergoing active aquifer restoration, additional bleed may be required at times. For example, additional restoration bleed may be used to recover flare of lixiviant outside of the well field pattern area. In addition to the restoration methods described above, Powertech (USA) may withdraw up to one pore volume of water through groundwater sweep over the course of aquifer restoration. This will result in an average restoration bleed of approximately 17%. The liquid waste disposal systems have been designed to accommodate both options and both options are depicted on the water balance.

The typical restoration extraction flow rate from the Dewey and Burdock well fields will be approximately 250 gpm each for a total of 500 gpm. The total project-wide restoration extraction flow rate will be approximately 500 gpm, while the specific contribution from the Dewey and Burdock well fields will vary. If groundwater sweep is not used, approximately 2.5 gpm less will be injected than is recovered. For the DDW option, RO treatment of the restoration solution typically will result in 175 gpm of permeate returning to each of the Dewey and Burdock well fields (Stream C for Burdock and Stream L for Dewey) and 75 gpm of liquid waste being routed to the DDWs (Stream I for Burdock and Stream N for Dewey). If land application is used for liquid waste disposal, all 250 gpm of the restoration extraction solution will be sent to the land application systems. In this case clean makeup water from the Madison Formation will be injected instead of permeate. Regardless of the disposal option, the balance of any water required to maintain the restoration bleed of 1% will be supplied from the Madison Formation.

If groundwater sweep of one pore volume is used, overall restoration bleed will average approximately 17%, resulting in 42 gpm being removed from the ore zone aquifer under both disposal options. Similar to the aquifer restoration option without groundwater sweep, the resulting liquid waste disposal flow rates will typically be 75 gpm for the DDW option and 250 gpm for the land application option.

Note that Streams F and H, which represent the flows from the Madison Formation to the CPP and from the CPP to liquid waste disposal, are typically zero during aquifer restoration without concurrent uranium recovery. While there will be times during this phase when liquid waste will be generated from the CPP, they will be infrequent due to the small number of resin transfers and elution and precipitation cycles during this phase. During this phase the water supply needs for the CPP will be nearly zero in the typical water balance.

4.2.2.4.3 Concurrent Uranium Recovery and Aquifer Restoration Water Balance

A typical water balance for concurrent uranium recovery and aquifer restoration is shown in Table 4.2-10. The table shows the typical combined flow from the Fall River Formation and Chilson Member and the flow from the Madison Formation. It also shows the typical liquid waste disposal flow rates under the different restoration options. The typical values for Fall River and Chilson flow rates were obtained by adding the Streams A and J in Figure 4.2-1 for both uranium recovery and aquifer restoration. The typical Madison Formation makeup water flow rate was obtained by adding Streams G and M in Figure 4.2-1 for uranium recovery and aquifer restoration. The liquid waste disposal flow rate was obtained by adding the Streams I and N in

Figure 4.2-1 for uranium recovery and aquifer restoration. The typical liquid waste flow rates during concurrent uranium recovery and aquifer restoration will be approximately 197 gpm for the DDW option and 547 gpm for the land application option.

4.2.2.4.4 Liquid Waste Disposal Capacity

Liquid waste disposal capacity using land application and DDW options is discussed in Section 4.2.2.1 and 4.2.2.2, respectively. In both liquid waste disposal options the planned capacity exceeds the anticipated liquid waste flow rate.

4.2.3 Potential Pollution Events Involving Liquid Waste

Although there are potential sources of pollution at the project facility, Powertech (USA)'s Environmental Management Programs combined with existing regulatory requirements from the NRC and DENR establish a framework that significantly reduces the possibility of an event. Additionally, extensive personnel training, which is standard policy for all Powertech (USA) operations, will be implemented at the project. Detailed procedures for inspections of waste management facilities and systems will be included in Powertech's (USA)'s Environmental Management Programs, which will be tailored for use at the project.

The following represent potential sources of pollution:

- Spills from well field buildings, pipelines, and well heads
- CPP and SF
- Deep well pump houses and well heads
- Domestic liquid waste

4.2.3.1 Spills from Well Field Buildings, Pipelines, and Well Heads

There will be no process chemicals or effluents stored within well field buildings or pipelines. As such, they are not considered to be a potential source of pollutants during normal operations. However, these well field features could contribute to pollution in the unlikely event of a release of injection or recovery solutions due to pipe or well failure. The chances of such a failure are minimized by leak checking the piping prior to installation. Additionally, the flows through the pipe will be at a relatively low pressure and can easily be stopped, further reducing the chance of a spill migrating far from the source. Well field header houses will be equipped with wet alarms for early detection of leaks, further minimizing the potential for a large event. Due to a decrease

in flow and pressure, large leaks in the pipe would quickly become apparent to the plant operators, and the release could be mitigated rapidly. All piping will be leak checked prior to installation and operation.

Generally, piping from the plant either to or within the well field will be constructed of PVC or high density polyethylene (HDPE) with butt welded joints or equivalent. All pipelines will be pressure tested before initial operation, and it is unlikely that a break would occur in a section of underground pipe as no additional stress is placed on the pipe. Piping from the well fields will be buried below the frost line, minimizing the possibility of an accident resulting in an event. Additionally, underground pipelines will further be protected from vehicles driving over the lines, which is a major source for potential failure. Typically, the only exposed pipes will be at the CPP, wellheads, and in the header houses in the well field, where trunk line flows and manifold pressures will be monitored for process control. All tanks and pipelines that contain fluids subject to freezing will be heat traced to maintain the contacts above the freezing point of the material. Header houses, valve vaults, and well head covers will contain electric heaters to prevent freezing temperatures from occurring in these structures (refer to Section 7.5.1.1).

Refer to Section 3.2.12 for a description of the leak detection systems that will be implemented in the well fields, pipelines and header houses. Engineering and administrative controls at the CPP will help to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.

4.2.3.2 Central Processing Plant

The CPP will serve as the hub for production operations at the project; therefore, the CPP will likely have the greatest potential for spills or accidents potentially resulting in the release of pollutants. Spills at the CPP could result from a release of process chemicals from bulk storage tanks, or from structural failure of either piping or bulk storage tanks.

Chemical storage tanks outside will be contained within a curbed area designed to accommodate at least 110 percent of the capacity of the largest tank plus a 25-year, 24-hour storm event to ensure containment during a potential precipitation event. Fuel storage tanks will be contained within concrete lined and fenced storage facility to prevent potential impacts to the surface.

The CPP will be designed such that any release of liquid waste will be contained within the structure. A concrete curb will be built around the entire process building and will be designed to contain the contents of the largest tank within the building in the event of a rupture. Refer to Section 7.5.7 for a description of the curb capacity. The pumping system will immediately be shut down in the event of a piping failure, limiting any further release. Liquid inside the CPP building, from either a spill or from washdown water, will be drained through a sump and then sent to the liquid waste system for disposal or treatment and land application.

4.2.3.3 Deep Disposal Well Pumphouses and Wellheads

Waste disposal well pumphouses and wellheads will be designed such that any release of liquids will be contained within the building or the bermed containment area surrounding the facilities. Liquid inside the building will be contained and then recycled to the liquid waste system. See also Section 3.2.12, which describes the instrumentation and control systems that will be implemented for deep disposal wells.

4.2.3.4 Domestic Liquid Waste

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

4.3 Transportation Vehicles

An accident involving transportation vehicles to and from the project site could potentially release pollutants to the environment. Transport vehicles at the project site include, but are not limited to: vehicles delivering bulk chemical products, transport of radioactive contaminated waste from the project site to an approved disposal site, or transport of waste brines from the CPP, or from vehicles carrying dried yellowcake product from the CPP.

Chemicals and products delivered to or transported from the project site will be transported in accordance with all SDDOT regulations. As part of Powertech's (USA)'s Environmental Management Program, emergency response procedures will be developed and implemented to ensure a rapid response to any transportation incidents. All appropriate personnel will be appropriately trained in emergency response procedures to facilitate proper response from Powertech (USA) employees in transportation incidents.

4.4 Solid Waste and Contaminated Equipment

4.4.1 11e.(2) Byproduct Material

Solid 11e.(2) byproduct material generated at the site is expected to include impounded 11e.(2) byproduct material extracted directly from the ISL process (radium removal and reverse osmosis units, spent resins, etc) as well as material contaminated with radionuclide by-products (miscellaneous pipe, pumps, fittings and similar items contaminated with low levels of radioactive "scale" and precipitates). The radiological contaminant will be primarily residual natural uranium and radium 226 (NMA 2007, Brown 2007, 2008). As radium will follow the process calcium chemistry, process pH and related chemical parameters will play a role in determining where and

how much residual by-product material becomes deposited in process components. Mobilization of other uranium series radionuclides (Th 230, Pb 210) has been indicated to be minimal (Brown 1982). Two categories of radioactive solid waste (i.e., "11e.(2) by-product material") are discussed, impounded by-product material extracted directly from the process and equipment contaminated with by-product material.

4.4.1.1 Impounded Byproduct Material

Small volumes of solid 11e.(2) byproduct material are typically generated at ISLs and need to be temporarily impounded at designated on-site locations pending further evaluation and/or shipment offsite. Temporary impoundment on-site typically involves designated ponds and/or tankage. Alternatively, the material may be drummed as produced.

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

Byproduct material requiring offsite disposal in accordance with NRC requirements and/or license conditions will be transported off site to an NRC or Agreement State licensed 11e.(2) disposal facility. Prior to transportation to a licensed disposal facility, byproduct material will be stored in designated storage buildings (also referred to as "byproduct storage buildings"), one located at the CPP site and one located at the SF site. These buildings will consist of a concrete slab with a containment curb surrounding the perimeter. Storage of byproduct material will be within "roll-off" containers (bins) which are both liquid tight and fully enclosed. As each storage building can accommodate two 20 cubic yard bins, the volume of byproduct material could accumulate to 30 to 40 cubic yards at each of the two storage locations prior to transport. There are two bays in each storage building, each accessed by an overhead roll-up door and allowing exchange of containers necessary for transport to a licensed 11e(2) disposal site. The concrete slabs will be designed to allow external decontamination of the roll-off bins prior to transport.

The byproduct storage buildings will allow for control of byproduct materials and specific segregation of these wastes from other non-11e(2) wastes. Typically these wastes are expected to consist of contaminated used equipment parts, personal protective equipment, and wastes from

cleanup of spills or other housekeeping activities. Other waste not in contact with the uranium production process will be disposed of in regular dumpsters situated at a separate location.

Containment of these byproduct wastes within a designated, fully enclosed building will allow for proper control of the materials, monitoring, and necessary restricted access. These measures will ensure best possible control of 11e(2)solid and liquid wastes to minimize any potential exposures or contamination.

Powertech (USA) estimates that the proposed project will produce approximately 100 yd^3 of solid or sludge 11e.(2) byproduct material per year from the radium ponds and from miscellaneous supplies. These materials will be stored on-site, properly labeled and posted inside the restricted area until such time that a full shipment can be transferred to a licensed 11e.(2) waste disposal site or licensed mill tailings facility in accordance with the requirements of the NRC.

4.4.1.2 Contaminated Equipment

This category of solid 11e.(2) byproduct material includes process and other ancillary equipment and materials that have become contaminated with low levels of by-product materials as a result of use and/or contact with process streams. Equipment and materials generated by this project that may become contaminated with by-product materials include items such as rags, trash, worn or replaced parts from equipment, piping, fittings, pumps, filters, protective clothing, etc. In some cases, reusable items with economic value (e.g., tools) may be decontaminated prior to release from the restricted area. If decontamination of equipment is deemed desirable and practical, surveys for residual surface contamination will be made before releasing the material from the restricted area. Decontaminated materials must have activity levels lower than those specified in Table 2 of NRC Regulatory Guide 8.30 (NRC, 2002).

4.4.2 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). On the basis of the processes and materials to be used on the project, it is likely that this project will be classified as a Conditionally Exempt Small Quantity Generator (CESQG), defined as a generator that generates less than 100 kg of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. In the event that Powertech (USA) is not classified as a CESQG, Powertech (USA) will obtain the appropriate approvals or permits. Powertech (USA) expects

that only used waste oil and universal hazardous wastes such as cleaning solvents and spent batteries will be generated at the project.

4.5 Reference

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5.0 Operations

During operation of the facility, Powertech (USA) via the company's Safety and Environmental Review Panel (SERP) will ensure that the facility will apply to all applicable laws and regulations. Powertech (USA) will also maintain the health and safety of the workers, general public, and the environment while the facility is in operation. This includes maintaining potential occupational and public exposures to ionizing radiation as low as reasonably achievable (ALARA).

5.1 Corporate Organization and Administrative Procedures

This section provides functional positions within the Powertech (USA) organization that have direct responsibility to ensure corporate commitment to operating the facility in a manner that is protective of human health and the environment, including the principle of ALARA. The organizational accountability of these functional positions is also presented.

5.1.1 Corporate and Facility Organization

The organizational structure of Powertech (USA) and the facility is shown in Figures 5.1-1 and 5.1-2, respectively. The organization structure defines Chief Operating Officer (COO) as having direct supervision over the Vice President of Environmental Health & Safety and the Facility Manager of the facility.

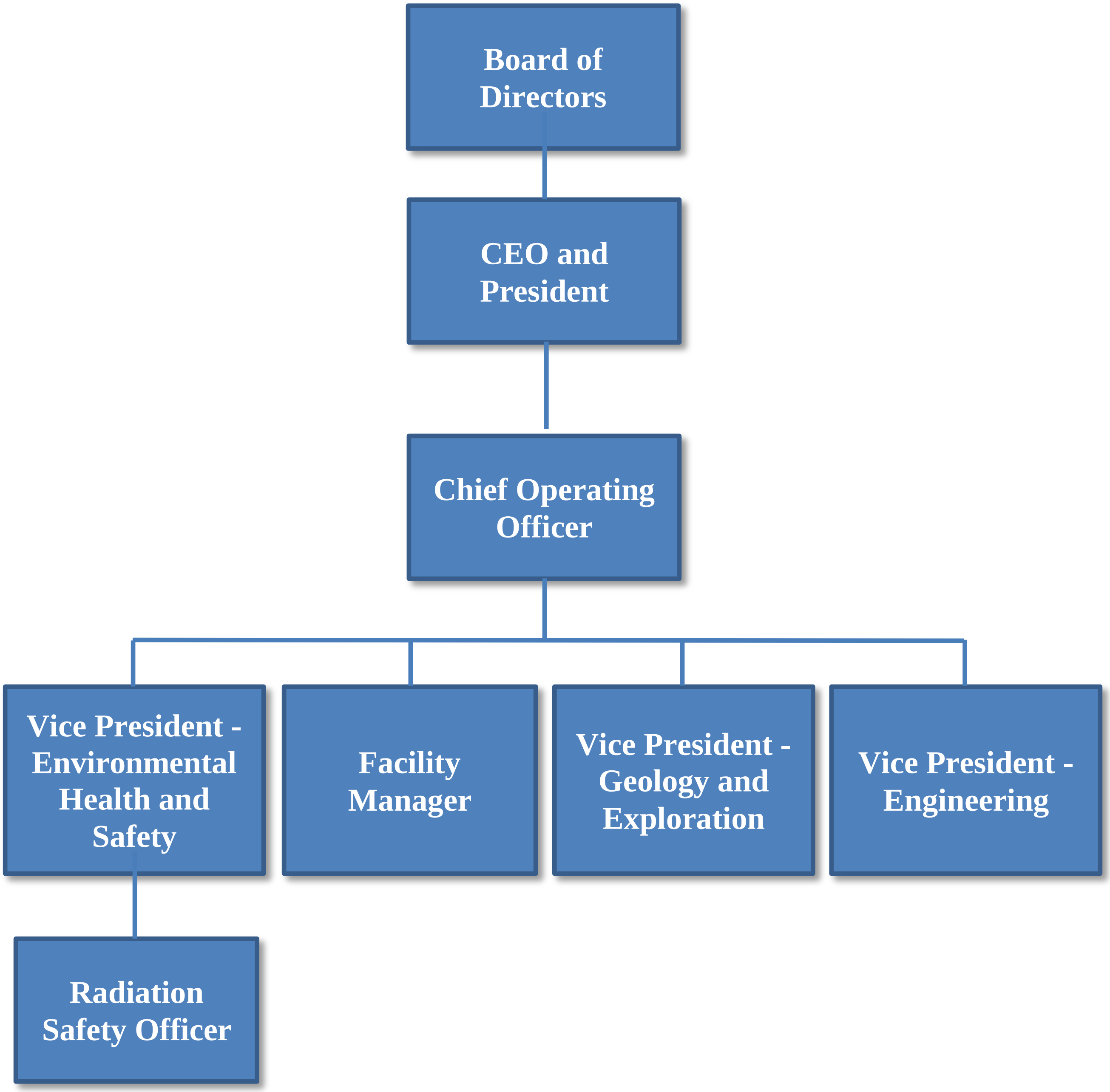


Figure 5.1-1: Organizational Structure

POWERTECH (USA) INC.

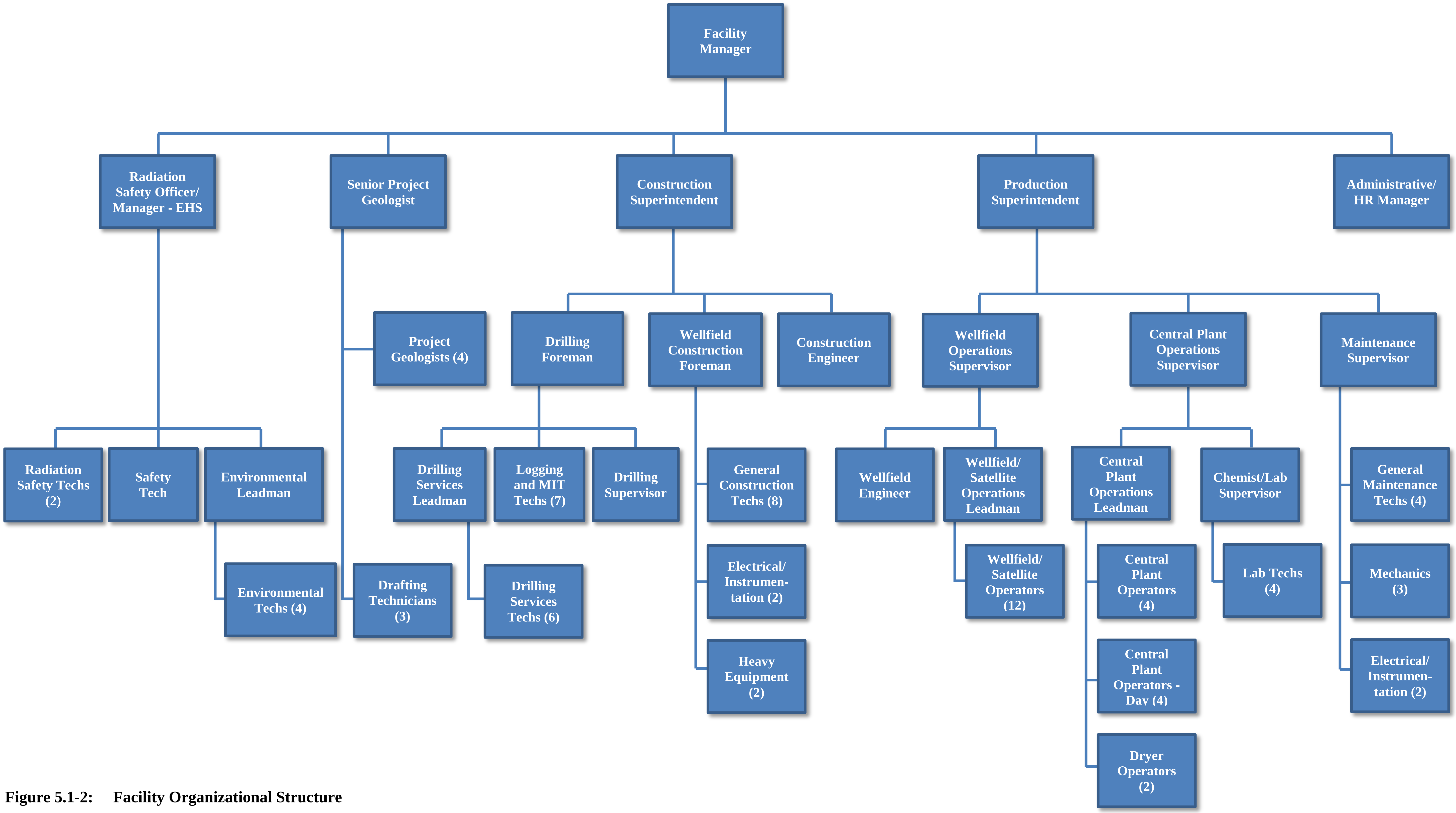


Figure 5.1-2: Facility Organizational Structure

5.1.2 Chief Operating Officer

The COO is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at all Powertech (USA) facilities. The COO is directly responsible for ensuring that Powertech (USA) personnel comply with corporate industrial safety, radiation safety, and environmental protection programs. The COO is also responsible for company compliance with all regulatory license conditions/stipulations, regulations, and reporting requirements. The COO has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees, public health, or the environment, or a violation of state or federal regulations. The COO has the authority to assign corporate resources (e.g. capital equipment, personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met.

5.1.3 Vice President of Environmental Health & Safety

The Vice President of Environmental Health & Safety is responsible for all radiation protection, health and safety, and environmental programs for Powertech (USA) and ensuring these programs meet applicable regulatory requirements and industry best management practices**.** The Vice President is responsible for ensuring that all company operations comply with all applicable laws and regulations. The Vice President reports directly to the COO.

5.1.4 Facility Manager

The Facility Manager will be responsible for all operations at the project facility. The Facility Manager will be responsible for compliance with all applicable laws and regulations as well as corporate health, safety and environmental programs. The Facility Manager will have the authority to terminate immediately any operation of the facility that is determined to be a threat to employees, public health, or the environment, or a violation of laws or regulations. The Facility Manager reports directly to the COO. The Facility Manager has the authority to assign facility resources (e.g. capital equipment, personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met. The Facility Manager will act promptly on recommendations made by the Radiation Safety Officer (RSO) to correct deficiencies identified in the radiation or environmental monitoring programs, but will not have the authority to unilaterally override the RSO's decision to suspend, postpone, or modify an activity.

5.1.5 Radiation Safety Officer

The Radiation Safety Officer (RSO) will be the person in charge of and responsible for the radiation protection and as low as reasonably achievable (ALARA) program. The RSO will

ensure that equipment and laboratory facilities are adequate for monitoring and evaluating the relative attainment of the ALARA objective. The RSO will develop, review, and enact changes in the program so that protection against uranium and its progeny and the ALARA principle are maintained during the operation of the facility. These changes include new equipment, process changes, and changes in the operating procedures.

The RSO will possess the authority to enforce regulations and administrative policies that may affect any aspect of the radiological protection program. The RSO will have the authority to suspend, postpone, or modify any activity that the RSO determines is not in compliance with regulations and administrative policy. The RSO will also be a member of the SERP described in Section 5.2.3 and will meet the qualifications outlined in NRC guidance.

The RSO reports directly to the Vice President of Environmental Health & Safety.

5.1.6 Radiation Safety Technician

Powertech (USA) will utilize Radiation Safety Technicians (RST; also referred to as Health Physics Technicians in RG 8.31). The RST will be a member of the radiation safety staff. Qualifications and training requirements are described in Section 5.4. The RST will meet the minimum training requirements of the RSO and will be a qualified designee to replace the RSO in daily visual inspection of all work and storage areas in the facility to determine if SOPs are being followed properly and good radiation practices are being implemented and in reviewing and signing radiation work permits (RWPs). The RST will perform these functions when the RSO is not available, e.g., during off shifts.

5.2 Management Control Program

This section describes administrative controls within the Powertech (USA) organization that are intended to ensure the facility is operated in a manner that is protective of human health and the environment, including the principle of ALARA.

5.2.1 Routine Activities

All routine activities involving handling, processing, or storing of radioactive material at the Dewey-Burdock facility will be documented by written standard operating procedures (SOPs). In addition, written SOPs will be established for health physics monitoring, sampling, analysis, and instrument calibration. These SOPs involving radioactive material handling will incorporate pertinent radiation safety practices.

Each SOP will be reviewed and approved in writing by the RSO or RST prior to implementation. Any proposed changes to an SOP must also be reviewed and approved in writing by the RSO or the RST. The RSO will review each SOP at least annually to ensure it follows any newly established radiation protection practices.

Up-to-date copies of the SOPs, along with accident response and radiological fire protection plans, will be made available to all employees. All SOPs will be managed in a manner which allows for tracking of revisions and dates of the revisions.

5.2.2 Non-Routine Activities

Any activities with potential for significant exposure to radioactive material and not documented by existing SOPs will require radiation work permits (RWPs). RWPs are job-specific permits that describe the following:

1. The details of the job to be performed,
2. Precautions necessary to maintain radiation exposures ALARA, and
3. The radiological monitoring and sampling necessary before, during, and following completion of the job.

The RSO or RST must review and sign off on the RWP before the associated work is to be performed. The RST will perform this function when the RSO is not available, e.g., during off shifts. The RST will meet the RG 8.31 requirement as a member of the radiation safety staff who has specialized radiation protection training and will be authorized to review and sign RWPs when the RSO is not available.

5.2.3 Safety and Environmental Review Panel

A SERP will be established. The SERP will consist of at least three members. One member will be the RSO. Another member will be someone with authority to implement managerial and financial changes (e.g. the Facility Manager). Another member will be someone with authority to make operational changes (e.g. the Production Superintendent). The SERP may include others on a temporary or permanent basis whenever the SERP requires additional technical or scientific expertise and may be other employees or consultants. At least one member of the SERP shall be designated as chairman.

The purpose of the SERP will be to evaluate, discuss, approve, and record any changes to any SOP, the facility, or tests and experiments involving safety or the environment. The changes will not require a license amendment pursuant to 10 CFR 40.44 as long as the changes do not:

- Create a possibility of an accident unlike what is evaluated in the license application (as updated)
- Create a possibility of a malfunction of a structure, system, or control unlike what is evaluated in this license application (as updated)
- Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report or the environmental assessment or technical evaluation reports or other analyses and evaluations for license amendments

Records of the evaluations made by the SERP will be made. These records will provide the basis for determining if the implementations of the changes do not require a license amendment

pursuant to 10 CFR 40.44. Any change approved by the SERP will be documented in writing by showing the affected operating procedure, facility, and/or test and experiment before and after the change along with the date of the change. Even though Powertech (USA) is a newly formed corporation, it possesses more than 200 years of technical experience with ISL operations. The SERP will evaluate each well field package as it is developed. The SERP evaluation will determine whether the results of the hydrologic testing and the planned ISR operations are consistent with SOPs and technical requirements stated in the source and byproduct material license. The evaluation will include review of the potential impacts to human health and environment. If anomalous conditions are present or the SERP evaluation indicates potential to impact human health or the environment, the well field package will be submitted to NRC for review and approval. Otherwise, the well field package and written SERP evaluation will be maintained at the site and available for NRC review.

The SERP will have the authority to raise issues regarding the health and safety of the workers, general public, and/or the environment due to the operation of the facility to the Facility Manager and the Vice President of Environmental Health & Safety.

An annual report will be prepared which describes actions taken by the SERP including changes to operating procedures, the facility, or tests and experiments that involve safety or the environment enacted since the previous report was issued. The report will also document the reason for each change, whether the change required a license amendment, and the basis for determination.

5.2.4 Radioactive Material Postings

In order to be exempted from the requirements of 20 CFR 1902(e), all entrances to the facility will be conspicuously posted with the following statement: “ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL.”

5.2.5 Record Keeping

All records will be maintained as hard copy originals or stored electronically.

The following information will be permanently maintained both on-site and at an off-site location until license termination:

- Records of on-site radioactive waste disposal.
- Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.
- Records of spills, excursions, facility stoppages, contamination events, and unusual occurrences.
- Records of inspections of waste retention systems.

- Records of the occupational monitoring described in Section 5.7.
- Information related to the radiological characterization of the facility.
- Drawing and photographs of structures, equipment, restricted areas, wellfields, and storage areas with radioactive materials and all of their modifications.

Additionally, records of survey and calibrations will be maintained for at least 3 years.

All records will be stored in manner to prevent record loss from fire, flood, or other unforeseen events beyond the control of Powertech (USA). All records will be legible throughout the retention period described above.

5.2.6 Reporting

Consistent with NUREG-1569, Acceptance Criterion 5.2.3(1), Powertech (USA) commits to the development of written operating procedures within the management control program to address reporting requirements in 10 CFR Part 20, Subpart M and 10 CFR §40.60. These include appropriate reporting requirements listed in RG 10.1, Compilation of Reporting Requirements for Persons Subject to NRC Regulations (NRC, 1981). Powertech (USA) will prepare the written operating procedures describing reporting requirements after license issuance but prior to ISR operations. Specific reporting requirements include, but are not limited to, the following:

- Reports of theft or loss of licensed material (10 CFR §20.2201),
- Notification of incidents (10 CFR §20.2202),
- Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the constraints or limits (10 CFR §20.2203),
- Reports of planned special exposures (10 CFR §20.2204),
- Reports to individuals of exceeding dose limits (10 CFR §20.2205),
- Reporting requirements under 10 CFR §40.60,
- Reporting requirements under 10 CFR §40.64,
- Effluent monitoring reporting requirements (10 CFR §40.65), and
- Requirements for advance notice of export shipments of natural uranium (10 CFR §40.66).

Consistent with 10 CFR 20.2202, Powertech (USA) will notify the NRC within 4 hours of any event that could cause a release of licensed material or an exposure to radiation or radioactive materials exceeding the regulatory limits.

Specific incident reporting requirements under 10 CFR §40.60 include notifying the NRC within 24 hours of any of the following events:

- An unplanned contamination event that involves a quantity of licensed material greater than 5 times the lowest annual limit on intake or requires restricted access to the contaminated area, by workers or the public, for more than 24 hours.
- Equipment necessary for control of radioactive material or radiation fails and there is no adequate redundancy/substitute.
- An event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body.
- An unplanned fire or explosion affecting the integrity of either a container of licensed material containing a quantity greater than 5 times the lowest annual limit on intake or the licensed material itself.

The NRC will be notified within 48 hours of any event in which spills, evaporation pond leaks, or excursions of source material and process chemicals occurred.

A written report will be made and sent to the NRC Headquarters Manager within 30 days of each event listed above. That report will contain details about the event including the conditions leading up to the event, corrective measures taken, and their results.

The following reports will be submitted to the NRC at the indicated frequency:

- Annually, a SERP report as described in Section 5.2.3.
- Semiannually, an effluent and environmental monitoring report as required by 10 CFR 40.65.
- Annually, the ALARA audit report detailed in Section 5.3.3.
- Annually, summary of monitoring data detailed in Section 5.7 and any corrective actions resulting from SERP actions, inspections described in Section 5.3 or reporting triggers described above.

- Annually, a Land Use Survey describing any changes to the land use within the license boundary or within 3.3 km of the license boundary in accordance with NUREG-1569, Acceptance Criterion 5.2.3(13).

5.2.7 Historic and Cultural Resources Inventory

Powertech (USA) will administer a historic and cultural resources inventory before engaging in any development activity not previously assessed by NRC or any cooperating agency. Any disturbances to be associated with such development will be addressed in compliance with the National Historic Preservation Act (NHPA), the Archeological Resources Protection Act, and their implementing regulations. Any disturbances also will be addressed in compliance with Powertech (USA)'s Memorandum of Agreement (MOA) with the South Dakota State Archeologist and any future MOAs developed by Powertech (USA) or NRC under the NHPA. Powertech (USA) executed the MOA with the South Dakota State Archeologist in September 2008. The MOA, which is provided in Appendix 2.4-B, establishes procedures to avoid or mitigate potential effects on archaeological and historic sites pursuant to South Dakota statutes 45-6D-14 and 45-6B.

Powertech (USA) will immediately cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Powertech (USA) will notify appropriate authorities per any license conditions and will not go forward without appropriate approvals from NRC or other agencies as appropriate. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until authorization to proceed has been received. The procedure described in this section will continue up to and through final license termination.

5.3 Management and Audit Program

This section describes management and audit programs Powertech (USA) will use to periodically evaluate compliance with and effectiveness of the radiation protection, operational monitoring, and environmental programs at the facility. A series of health physics inspections and audits of the radiation protection and ALARA programs will be conducted.

Licensee management items in Regulatory Guide 8.31, Section 1.1 are listed below followed by the appropriate section where each commitment is made within the respective discussion of the applicable program and/or management schema described.

1) A strong commitment to and continuing support for the development and implementation of the radiation protection and ALARA program.
   Addressed in Section 5.0.
2) Information and policy statements to employees, contractors, and visitors.
   Addressed in Section 5.5.
3) A periodic management audit program that reviews procedural and operational efforts to maintain exposures ALARA.
   Addressed in Section 5.3.
4) Continuing management evaluation of the radiation safety (health physics) program, its staff, and its allocation of adequate space and money.
   Addressed in Section 5.0 and Section 5.3.
5) Appropriate briefings and training in radiation safety, including ALARA concepts for all uranium employees in the facility and, when appropriate, for contractors and visitors.
   Addressed in Section 5.5, Section 3.3, Section 4.2.3, Section 5.3.4, and Section 5.4.

Powertech (USA) is confident that the information contained within the application is in line with the general operating philosophies acceptable to the NRC staff as described in Regulatory Guide 8.10. The application strongly supports the management's commitment to maintaining exposures ALARA and reducing exposures when possible. This is demonstrated throughout the report, including the following sections: 4.1.1 Radon; 4.1.2.2 Atmospheric Discharges from the Yellowcake Drying and Packaging System; 5.0 Operations; 5.1 Corporate Organization and Administrative Procedures; 5.1.5 Radiation Safety Officer; 5.2 Management Control Program; 5.3 Management and Audit Program; 5.3.4 ALARA and Radiation Protection Program; 5.5.1 Initial Training; 5.7 Radiation Safety Controls and Monitoring; 6.3.2 Preliminary Radiological Surveys and Contamination Control; 6.4.1.3 Uranium Chemical Toxicity Assessment; and 6.4.3 Surface Soil Cleanup Verification and Sampling Plans.

5.3.1 Health Physics Inspections – Daily

The RSO or RST will conduct a daily visual inspection of all work and storage areas in the facility. The purpose of these inspections is to determine if good radiation practices are being implemented properly, including minimization of contamination through proper housekeeping and cleanup, SOPs are being followed, and if issues identified in prior inspections have been addressed and corrected.

The criteria used to determine who is a qualified RST to replace the RSO in daily visual inspections of all work and storage areas in the facility to determine if SOPs are being followed properly and good radiation practices are being implemented are: A) satisfy one of the alternative requirements for education, training and experience as described in RG 8.31 and summarized in Section 5.4, and B) demonstrate a working knowledge of: i) the proper operation of health physics instruments used at the facility, ii) surveying and sampling techniques, iii) personnel dosimetry requirements, iv) which locations, operations and jobs are associated with the highest exposures, and v) why exposures may increase or decrease during work execution. The criteria are consistent with Section 2.4.2 of Regulatory Guide 8.31.

5.3.2 Health Physics Inspections – Weekly

Once a week, the RSO and Facility Manager will perform an inspection of all facility areas. The purpose of these inspections is to examine the general radiation control practices and observe the required changes in procedure and equipment.

Procedural deviation or other issues potentially affecting facility compliance, health and safety, or environmental impacts found during the inspections will be recorded in an inspection logbook or equivalent tracking system along with the date of the inspection and the signature of the inspector. These entries will be kept on file for at least a year. The RSO will discuss the problems with members of management that have the authority and responsibility to rectify them.

Additionally, the RSO will review the shift logs and daily work-orders, on a regular basis, where there was potential of exposing employees. The RSO will determine if each action was

authorized in writing by a person with the proper authority (the RSO or RST).

5.3.3 Health Physics Reviews – Monthly

At least monthly, the RSO will review the results of daily and weekly inspections, including a review of all monitoring and exposure data for the month. The RSO will then write a report summarizing the significant worker protection activities for the month. The report will summarize the most recent personnel exposure data, bioassays, and time-weighted calculations for the month along with the pertinent radiation survey records for the month.

Additionally, the monthly reports will discuss any trends or deviations from the radiation protection and ALARA program, including an evaluation of the adequacy of the implementation of license conditions regarding radiation protection and ALARA. The reports will also provide a description of unresolved issues and the proposed corrective measures. Monthly summary reports will be submitted to the Facility Manager and made available to the Senior Project Geologist, Construction Superintendent, Production Superintendent, and Administrative/HR Manager. These monthly RSO reports will be maintained on file and readily accessible for at least 5 years.

5.3.4 ALARA Requirements and Radiation Protection Program

Goal of the Radiation Protection Program:

Powertech (USA) will develop, document and implement a radiation protection program commensurate with the scope and extent of the licensed activities that will ensure compliance with the provisions in 10 CFR § 20.1101. The radiation protection program will include implementing procedures and conducting operations in such a manner as to reduce airborne effluent releases to levels that are ALARA. The program's primary function will be to ensure doses to workers and members of the public are ALARA. A summary of the means by which this goal will be accomplished is described below.

Institutional Controls:

<u>Management and Audit Program</u>: The management and audit program will function to ensure vigilance toward the protection of human health and the environment. The management and audit program will be designed to provide quality assurance based upon reviews and evaluations of the effectiveness of radiation protection provided for workers and members of the public (MOP). Specifically, the semiannual effluent report required by 10 CFR § 40.65 will specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in

gaseous effluents during the previous six months of operation, and such other information as the NRC may require to estimate maximum potential annual radiation doses to the public resulting from effluent releases.

Powertech (USA)'s goal of the radiation protection program is to ensure doses to workers and the MOP are ALARA, consistent with 10 CFR § 20.1101(b).

Inspections and Audits Performed to Ensure ALARA Goal:

- Accident reports and corrective action plans
- Effluent monitoring programs and air emissions restriction plan
- Emergency plans
- Radiation exposure records and monitoring program
- Security of licensed materials on site
- Retention system program and reports
- Transportation of licensed material
- Environmental monitoring program
- Inspection and documentation of equipment operation to ensure the equipment is operating consistently near peak efficiency. This includes drying and packaging operations
- Other institutional controls that will be utilized to prevent and minimize the potential for exposure to MOP including the remoteness of the project area and restriction of land and groundwater use

Engineering Controls:

Constraint on Radioactive Effluents to Air: Powertech (USA) will establish a plan to restrict air emissions of radioactive material to the environment, excluding radon-222 and decay products, to ensure that the individual MOP likely to receive the highest dose will not be expected to receive a total effective dose equivalent (TEDE) in excess of 10 mrem (0.1 mSv) per year from these emissions. If an over exposure does occur, Powertech (USA) will promptly report the incident according to 10 CFR § 20.2203 and implement corrective action and preventative measures against recurrence.

Effluent Control and Monitoring: This program will establish the control and monitoring system utilized for the facility and ensure monitoring locations are optimized for the intended function. The monitoring system will be utilized to assess the worker and MOP exposures. The system

will be designed in a manner that is appropriate for the types of effluent(s) generated at the facility. Adequate ventilation systems will be installed, maintained and monitored to ensure exposures are ALARA.

Waste Storage Program: Powertech (USA) will develop and implement a waste storage system that will ensure that the design and installation is conducted in such a manner as to assure any dose that may result is ALARA. A monitoring program will be established for the waste storage system that will ensure the ponds are operated and maintained in a manner that prevents the movement of waste(s) to undesirable areas. Contingency plans will be built into the program to address all reasonable system failures.

Additional engineering controls that will be utilized to minimize the potential for exposure to MOP include locating the CPP near the center of the proposed license area, optimizing the number of well fields in operation at one time, fencing, signage, physical access controls, and groundwater monitoring systems.

The implementation of institutional and engineering controls will ensure to the extent practicable that the TEDE to individual members of the public from the licensed operation does not exceed 0.010 rem/yr (10 mrem/yr).

Public Exposure at ISR Facilities:

According to NUREG-1910 (pg. 3.2-81), the TEDE to the average U.S. resident from natural background and man-made sources is 360 mrem/yr. NRC's regulations in 10 CFR Part 20 specify annual dose limits to MOP of 1 mSv (100 mrem) TEDE (above background). The potential for exposure of MOP to TEDE greater than the annual dose limits from an ISR facility is very remote. As described in pg. 4.2-55 of NUREG-1910, "Because of the distance to offsite receptors, radiological doses from normal operations are expected to have a SMALL impact on the general public." Further, the Generic Environmental Report in Support of the Nuclear Regulatory Commission's Generic Environmental Impact Statement for In Situ Uranium Recovery Facilities (NMA, 2007) concludes, "With respect to ISR operations, the potential impacts from radiation dose are, by orders of magnitude, lower than those posed by conventional mining/milling.

"Many of the dose pathways relevant to conventional mining/milling, such as ore removal, hauling, ore storage, mill tailings, and wind-blown particulates are not present, and therefore do not pose any risk, at ISR facilities, since no ore or waste rock is brought to the surface and there

are no tailings associated with ISR activities. Thus, it is anticipated that the potential doses to actual members of the public who live near ISR facilities will be significantly lower, on the order of 1 mrem/year which equates to NCRP's negligible individual risk level (NIRL). Thus, it is highly unlikely that an ISR worker, much less a member of the public [even one who works occasionally within the project area], will receive a dose in excess of 10 CFR § 20.1301 regulatory limits."

This is demonstrated in Section 5.7.7.12. The analysis presented in this section shows that public and occupational exposure to radon decay products will be far below regulatory limits.

Annual ALARA and Radiation Protection Program Audit:
The ALARA and radiation protection program will undergo audits annually. The audits will be performed by a team consisting of people who are knowledgeable about the radiation protection program at the facility. One team member will be experienced in the operational aspects of radiation protection practices specific to uranium recovery facilities. The RSO will not be a member of the audit team but will be available to support the team and provide needed information.

A written report of the audit will be sent to the Vice President of Environmental Health & Safety and Facility Manager. At a minimum, the reports will summarize the following data:

- Employee exposure records (external and internal)
- Bioassay results
- Inspection log entries and summary reports of daily, weekly, and monthly inspections
- Documented training program activities

- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on overexposure of workers submitted to the NRC
- Operating procedures that were reviewed during this time period

Also, the reports shall include the following:

- Trend evaluation of personnel exposures for identifiable categories of workers and types of operational activities
- Assessment of whether equipment for exposure control is being properly used, maintained, and inspected
- Recommendations on ways to further reduce personnel exposures from uranium and its progeny

5.4 Qualifications for Personnel Implementing the Radiation Safety Program

The minimum qualifications for the RSO are:

- A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in radiation protection at a uranium recovery facility. Two years of relevant experience will generally be considered equivalent to one year of academic study.
- At least one year of uranium recovery work experience in applied health physics, radiation protection, industrial hygiene, or similar area. This experience should involve hands-on work with radiation detection and measurement equipment, not strictly administrative work.
- At least four weeks of specialized classroom training in health physics.
- A thorough knowledge of the health physics instrumentation used in the facility, the chemical and analytical procedures used for radiological sampling and monitoring, methods used to calculate personnel exposure to uranium and its progeny, the uranium recovery process, and the facility hazards and their controls.

The minimum qualifications for the RST will include:

- Training equal to the minimum qualifications of the appointed RSO as specified in Section 2.4 of RG 8.31.
- Must pass a test with an 80 percent score or better regarding the minimum training of the RSO.
- The level of experience required will be commensurate with the type, form and the anticipated radiation hazards to be encountered while acting as a designee for the appointed RSO.

On-the job training overseen by the RSO will provide expertise regarding implementation of site-specific radiological safety protocols and any necessary specialized radiation safety training concerning a specific RWP. For more information see Section 5.2.2. The minimum combination of education, training, and experience for an RST includes the following:

- An associate's degree or two or more years of study in the physical sciences, engineering, or a health-related field; at least four weeks of generalized training in

radiation health protection applicable to uranium recovery facilities (up to two weeks may be on-the-job training); and one year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures that apply to uranium recovery facility operations; or

- A high school diploma; at least three months of specialized training in radiation health protection relevant to uranium recovery facilities (up to one month may be on-the-job training); and two years relevant work experience in applied radiation protection.

5.5 Radiation Safety Training

This section describes minimal training requirements to ensure all employees and visitors have an adequate level of knowledge to recognize and are aware of potential radiological hazards associated with activities they will be involved with at the facility. Appendix 5.5-A provides written radiological safety instructions for workers.

5.5.1 Initial Training

Prior to working at the facility, all facility workers and supervisors subject to occupational radiation dose limits (i.e. radiation workers) will be instructed by means of a documented training class in the risks of radiation exposure and the fundamentals of protection against exposure to uranium and its progeny. Other guidance to be provided as appropriate is found in NRC Regulatory Guide 8.13 *"Instruction Concerning Prenatal Radiation Exposure"* and NRC Regulatory Guide 8.29 *"Instruction Concerning Risks From Occupational Radiation Exposure"*. The course of instruction will include the following topics:

- Fundamentals of Health Protection
  - The radiological and toxicological hazards of exposure to uranium and its progeny
  - How uranium and its progeny enter the body (inhalation, ingestion, and skin penetration)
  - Why exposures to uranium and its progeny should be kept ALARA
- Personal Hygiene
  - Wearing protective clothing
  - Using respirators correctly
  - Eating, drinking, and smoking only in designated areas
  - Using proper methods for decontamination (for example, showers)

- Facility-Provided Protection
  - Ventilation systems and effluent controls
  - Cleanliness of the work place
  - Features designed for radiation safety for process equipment
  - SOPs
  - Security and access control to designated areas
  - Electronic data gathering and storage
  - Automated processes
- Health Protection Measurements
  - Measurement of airborne radioactive materials
  - Bioassays to detect uranium radionuclides
  - Surveys to detect contamination of personnel and equipment
  - Personnel dosimetry
- Radiation Protection Regulations
  - Regulatory authority of the NRC, Mine Safety and Health Administration (MSHA), and Occupational Health and Safety Administration (OSHA)
  - Rights of employees in 10 CFR Part 19
  - Requirements for radiation protection in 10 CFR Part 20
- Emergency/contingency Plans

A written or oral test with questions directly related to the training topics will be given to each worker. The instructor will review the test results and discuss incorrect answers with each worker. Workers who fail the test (less than 70 percent correct) will be retested after receiving additional training.

All new workers will be given specialized instruction on the health and radiation safety aspects of the specific jobs they will perform. This instruction will be in the form of individualized on-

the-job training. Radiation safety matters of concern that arise during operations will be discussed with all workers during regularly scheduled safety meetings.

Powertech (USA) also commits to the development of a program for training on identification of, standards for, and health and safety procedures for nonradiological hazards. The training will be based on OSHA regulations and will address occupational safety (ergonomics, drug and alcohol abuse in the work place, hazardous material handling, confined spaces, etc.), general safety (hazard recognition, security, etc.), and job-specific categories of training for employees whose job function includes construction, electrical work, hazardous materials handling, or operation of machinery.

Prenatal and Fetal Exposure Policy

To ensure that the radiation dose to an embryo/fetus during the entire pregnancy of a declared pregnant worker does not present a health threat and is maintained ALARA, Powertech (USA) will take the following steps:

1) Advise all female workers of child-bearing age at the time of employment that if they are pregnant or become pregnant during their employment, they can voluntarily declare their pregnancy to Powertech (USA) to limit radiation exposure to their unborn child. Powertech (USA) will provide copies of this policy to all female employees.
2) Powertech (USA) encourages pregnant women to declare their pregnancy in order to protect the embryo/fetus.
3) In addition to providing instruction in accordance with §19.12 of 10 CFR Part 19, provide to all female employees instruction specified by NRC’s RG 8.13, specifically concerning biological risks to the embryo/fetus exposed to radiation, the dose limit for the embryo/fetus and suggestions for reducing radiation exposure.
4) Limit the exposure to the unborn child from occupational exposure of the expectant mother to 500 millirems for the entire pregnancy, if the pregnancy has been declared by the mother.
5) Avoid assigning job duties that could result in substantial variations in the rate of exposure.

5.5.2 Refresher Training

Each radiation worker and supervisor will be provided annual refresher training. Refresher training will include relevant information that has become available during the past year, a review of safety problems that have arisen during the year, changes in regulations and license conditions, exposure trends, and other current topics.

5.5.3 Visitor Training

All visitors who enter process areas and have not received training described in Section 5.5.1 will be escorted by someone trained and knowledgeable about the hazards at the facility. At a minimum, visitors will be instructed specifically on what they should do to avoid possible hazards (radiological and nonradiological) in the areas of the facility they will be visiting.

5.5.4 Contractor Training

Contractors that have work assignments at the facility will be given appropriate training and safety instruction. Contract workers who will perform work on heavily contaminated equipment or within the process area shall receive the same training and radiation safety instruction normally required of all radiation workers. Only job-specific radiation safety instruction is necessary for contract workers who have previously received full training on prior work assignments at the facility or have documentation of recent and relevant radiation safety training elsewhere.

5.5.5 RSO Training

The RSO will receive a minimum of 40 hours of documented refresher training in health physics at least once every two years.

5.5.6 Training Documentation

All workers will be required to sign a statement that they have received radiation safety training. The statement will indicate the content of the training and the date(s) the training was received. The statement will be co-signed by the instructor. This documentation applies to initial and refresher training.

5.6 Facility Security

As required in 10 CFR 20, Subpart I, Powertech (USA) will secure from unauthorized removal or access licensed materials stored in controlled or unrestricted areas using the following passive and administrative controls:

- All areas where licensed material is stored (e.g. well fields, CPP, SFs will be fenced.
- All gates accessing areas where licensed material is stored will be posted as described in Section 5.2.4 and locked when facility personnel are not immediately available to prevent unauthorized access to or removal of licensed materials.
- Facility fences, gates, and postings will be inspected daily as part of the inspection programs described in 5.3.1 and 5.3.2.
- A 24-hour per day, 7 day per week staff will be on duty at the facility.
- Visitors to the facility will enter through an access point at the main plant entrance where they will sign in and receive training required in Section 5.5.3.

Powertech (USA) will control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and is not in storage. An example of licensed material not being in storage is licensed material being transported from the SF to the CPP. Passive and administrative controls to prevent unauthorized access to and removal of licensed material not in storage include:

- SOPs assessing the possible transportation security risks and identifying measures to mitigate these risks
- Locks and/or tamper indicators on all openings where licensed material is kept
- Off-site vehicles transferring licensed materials will always be secure if left unattended
- Off-site vehicles transferring licensed materials will be visible by an employee at all times when left unattended outside of a restricted area

The requirements of 49 CFR 172 will apply to shipments of licensed material which Powertech (USA) offers for transport for commercial use. Powertech (USA) will develop SOPs for these cases and will evaluate the ability of potential commercial contractors offering transportation services to comply with the requirements of 49 CFR 172 prior to entering into a contracting agreement.

5.7 Radiation Safety Controls and Monitoring

This section describes the active and passive effluent control techniques used to ensure that occupational and public doses of ionizing radiation will be ALARA. The monitoring program used to confirm that ALARA is attained is also described.

5.7.1 Effluent Control Techniques

The project will generate effluent typical of other ISL facilities. Both the Dewey site and the Burdock sites will include well field and IX operations with similar effluents and effluent control techniques. At the Burdock site, the CPP will also produce effluents typical from a yellowcake processing facility.

Airborne emissions of concern include the release or potential release of radon-222 and dried yellowcake dust. Liquid phase effluents consist of well field bleed streams that will contain both uranium and radium, as well as a liquid brine stream from the CPP. Solid wastes include contaminated equipment and protective clothing as well as solid residues from settling and evaporation ponds.

Monthly "grab" sampling of the treated wastewater streams generated at the facility, and stored in the respective storage reservoir, will be necessary to demonstrate that the barium chloride treatment systems are operating properly and treating radium-226 concentrations to maintain regulatory compliance.

5.7.1.1 Airborne Effluents

Under routine operation radon-222 would be the only effluent of concern from production and restoration solutions. The airborne particulate of most concern in an ISL facility is yellowcake dust. Yellowcake drying will be conducted in hot-oil rotary dryers operated under vacuum to prevent the release of uranium during drying. Powertech (USA) will operate in conformance with 10 CFR Part 40, Appendix A, Criterion 8 to assure that all airborne effluent releases are ALARA. Powertech (USA) will use a non-emissions vacuum dryer, which has no exhaustible effluent and therefore no stack or stack emissions. According to NUREG-1910 (Table 7.4-1), use of vacuum dryers is a listed Best Management Practice. Routine wash-down procedures will keep work areas clean of accumulating uranium as well as dirt and dust from outside sources. Yellowcake is only present as a dry solid from the end of the dryer cycle through packaging operations.

The process facility is designed such that the dryer and packaging operation are contained within a separate room, with its own HVAC system as well as a sealed hood system to prevent leakage of yellowcake solids during transfer from the dryer to the packaging drums. A dedicated air

handler equipped with high efficiency particulate air (HEPA) filters will ventilate the dryer and packaging room and will provide an additional level of controlling particulate emissions.

The principles of 10 CFR Part 40, Appendix A, Criterion 8 regarding hourly monitoring and logging to ensure the vacuum dryer is operating near or at peak efficiency will be followed. To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signals an audible alarm at the dryer and in the CPP control room if the air pressure (i.e. vacuum level) falls below specified levels, and the operation of this system is routinely monitored during dryer operations. The operator will perform and document inspections of the vacuum level hourly or more frequently during dryer operations. Powertech (USA) staff also will perform a manual check of the vacuum alarm before each packaging event. Additionally, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

The venting systems described above will be completely separate from the building heating, ventilating, and air conditioning (HVAC) system. The HVAC system will be on when the buildings are normally closed due to weather or other factors.

Pregnant lixiviant will come into the SF and some radon-222 will be present. The lixiviant will be directed to the down-flow IX vessels to separate out uranium.

At both the SF and the CPP, the air/vacuum relief valves on the IX columns will be piped together in a manifold which will be vented above the roofline of the building. In addition, a flexible duct designed to attach to tanker trucks during loading and unloading of resin will be connected to this vent manifold. Pressure transmitters and pressure gauges on the inlet and outlet piping connected to each vessel will measure and indicate pressure both locally and in the control room. This vent system will not have a fan because vacuum relief requires an inflow of air. This vacuum relief system will minimizes exposure to personnel.

Small amount of radon-222 may be encountered during a spill, filter changes, IX resin transfer operations and maintenance activities. Exhaust fans will be placed in key areas of the building to remove any radon that may be released inside the building. Based on similar facilities historical operational experience, personnel exposures are not expected to be significant.

Consistent with RG 8.30 and to ensure airborne effluents are ALARA according to 10 CFR 20.1301, a ventilation survey will be conducted daily in areas with airborne radioactivity. The survey will be performed by the radiation safety staff during a daily walk through of the facility. Surveys will consist of operational checks of ventilation systems, to ensure they are operating effectively. Whenever equipment or procedures in the CPP or the Satellite Facility are changed in a manner that affects ventilation, the radiation safety staff will conduct a ventilation rate survey using an anemometer or pitot tube to ensure that the ventilation system is operating effectively. The verification procedure will also ensure effluent is within ALARA constraints established under 10 CFR 20.1101(d). Also, the principles in RG 3.56 regarding routine equipment inspections on the ventilation and effluent control equipment will be implemented to ensure radiation safety protocol. More detailed information on effluent controls are discussed in Sections 3.0 and 4.0 of this application. Inspections of radiation controls and equipment will be conducted during radiation safety inspections as discussed in Section 5.3.1.

5.7.1.2 Liquid Effluents

Liquid effluents consist of two types:

Liquid Process Waste

Liquid effluents from the operation will include: production bleed, groundwater generated during aquifer restoration, process solutions, affected well development water, plant wash-down water, laundry water, analytical laboratory waste, and facility sanitary waste. Refer to Section 4.2 for a description of liquid waste disposal options and water balance diagrams.

The net production bleed stream will flow at a rate of one half to three percent of the flow rate of production composite. Production bleed will be routed to either the wastewater disposal system or the production bleed RO unit. The restoration bleed will typically be 1 percent of the restoration flow rate unless groundwater sweep is used, in which case the average restoration bleed will be approximately 17 percent. Both production composites removed during recovery and restoration streams will first be treated in the IX columns to remove uranium to low levels. The restoration stream will undergo treatment that depends on the liquid waste disposal option. The restoration stream will be treated by RO in the deep disposal well option, with the brine undergoing treatment in lined settling ponds prior to disposal in DDWs. In the land application option, the entire restoration stream recovered from the well field will be treated in lined settling ponds prior to seasonal application through center pivot sprinklers. All liquid process waste streams will be treated to remove radium by the addition of a small amount of barium chloride and the settling out of the resultant barium-radium sulfate solids in a settling pond. After radium removal, the pond water will be pumped to one or more deep disposal wells and/or land application sites.

Water balance diagrams depicting typical liquid waste flow rates during ISR uranium recovery, aquifer restoration, and concurrent uranium recovery and aquifer restoration are presented in Section 4.2.2.4.

Aquifer Restoration

The technology selected for aquifer restoration will depend on the liquid waste disposal option. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. Groundwater restoration methods are described in Section 6.1.3.

Facility sanitary waste will be relatively small in quantity and will be treated in an appropriately sized septic system with sanitary drain field.

5.7.1.3 Spill Provision Plans

Procedures to address potential spills will be the responsibility of the radiation safety department; engineers and operations supervisors will assist in development of procedures. The SERP will review the procedure for effectiveness. Procedures developed will implement appropriate protocol to handle potential spills of radioactive materials. Nine responsibilities comprise basic activities:

- Resources and manpower assigned.
- Material and Inventory.
- Identification of potential spill sources.
- Spill reporting and visual inspection program established.
- Review of past spill incidents.
- Coordination among all departments for containment of spills.
- Emergency response protocol established.
- Program implementation, review and updating.
- New construction and changes in process relative to prevention and control of spills will be reviewed.

There are two types of spills that may result from an in situ operation:

Surface Releases

Potential surface releases may be the result of a tank failure, ruptured pipe, or transportation incident.

Failure of a process vessel will be contained within the CPP via concrete containment curbs and directed into a sump (equipped with a level alarm) that will transport the solution to the appropriate tank or disposal system.

Measures for Preventing Tank Failures

Section 4.2.3.2 and the provisions of 40 CFR Part 68, and others, will be followed to prevent tank failures. The primary methods for prevention of tank failure include the following:

- routine inspection
- installation of devices to avoid over pressurization or excessive level
- use of tanks and vessels that meet applicable ASME and/or ASTM codes appropriate to their function and operating conditions.
- proper engineering design of tanks and supporting structures, foundations, and footings.

Methods of Containing Tank Failures

The facility floors will be surrounded by 6-inch containment curbs and sloped toward the trench drains and sumps. Spilled or leaked fluid will be transferred to the waste tanks, from which it can be directed to liquid waste treatment and disposal. If a spill occurs in the recovery area, the spilled fluid could also be returned to the process circuit for processing, or stored temporarily in the Central Plant Pond.

Capacity of the Curbed Areas

The CPP and the Satellite Facility buildings will be designed with concrete containment curbs around the building perimeters. The largest liquid-containing vessel in the CPP is the yellowcake thickener with a capacity of 37,500 gallons (5,000 ft^3). Two vessels are currently planned for a combined capacity of 75,000 gallons (10,000 ft^3). A 6-inch high containment curb around the entire perimeter of the CPP floor would contain 10,750 ft^3. This would be more than enough to contain the entire contents of both thickeners in the extremely unlikely event that both thickeners should fail simultaneously and spill their entire contents onto the floor of the CPP before any of the contents flowed into the sump. The sumps will provide additional temporary containment capacity such that the total containment capacity of curbs and sumps is above 200% of the largest liquid-containing tank or vessel in the CPP. The thickeners will be separated by sufficient distance that collapse of the support footing for one thickener could not cause that thickener to fall into the second thickener. Standard operating procedures and employee training will be in place for emergency situations including spills in the CPP and Satellite Facility.

For the Satellite Facility, the largest liquid-containing vessel will be the utility water tank, with a volume of 16,000 gallons (2,139 ft^3). The Satellite Facility will include a 6-inch high containment curb around the perimeter wall of the building slab. The containment curb capacity will be at least 7,680 ft^3, or more than 350% of the volume of the utility water tank. Sumps will provide additional incremental containment capacity. Sump pumps will direct the spill to the radium settling pond for treatment and disposal. Depending on the nature of the spilled fluid, the sump pumps may be used to pump the spilled fluid through the ion exchange system for removal of uranium and other dissolved constituents prior to disposal.

Spilled fluids will be removed from the sumps by pumps and transported to the appropriate disposal system or recycled back to the appropriate process component. The primary contingency for spills within the elution and thickening area of the CPP is placement of the spilled liquid in the Central Plant Pond. This pond will have minimum capacity of 15.2 ac-ft (662,112 ft^3) not including allowance for storm water, or over 66 times the combined volume of both thickeners. At full level there is 3 ft of freeboard, which amounts to over 174,000 ft^3, or over 17 times the combined volume of both thickeners. Stated another way, with the Central Plant Pond full to its normal capacity, the addition of 10,000 ft^3 of liquid would increase the liquid depth in the pond by less than 0.2 ft.

<u>Likely Consequences of Leak or Spill Events</u>

The design of the process buildings (CPP and Satellite Facility) will include curbed foundations as noted previously, such that any spill will be contained within the building, regardless of sump pump operation. In the event of a total electrical failure, such that no pumps would be operational, a spill due to a vessel failure would be contained within the building in which the vessel failure occurred.

Piping system leaks is the most common source of surface releases that occur at an in situ facility. Generally these spills are small due to engineering controls set up to detect changes in pressure within the piping systems. Operators are alerted via an alarm system when pressure changes occur. Well field piping systems are constructed of PVC or high density polyethylene (HDPE) materials with butt welded joints or the equivalent. All pipelines will be pressure tested at operating pressures before put online. No additional stress is placed on the buried pipes so it is improbable a break would occur. The underground portions of the pipes are protected from vehicles and exposed pipes only occur at the wellheads and header houses. Trunkline flows and wellhead pressures will be monitored for process control. Spill response is specifically addressed in the Emergency Response Procedures (Energy Metals Corporation, U.S, 2007).

Spills related to transportation will be addressed in Powertech (USA)'s Emergency Response Action Plan. Specific actions involving response to a radioactive materials shipment will include instructions for appropriate packaging, documentation, driver emergency and accident response procedures and cleanup and recovery protocol.

Subsurface Releases

Potential subsurface releases such as a well excursion may result in the migration of process fluids.

Monitoring wells will be set up around the well field for detection of any leach fluids that may potentially migrate away from the production zone due to an imbalance in well field pressure. The monitoring well detection system is a proven method historically among ISL operations. Powertech (USA) proposes to locate a ring of monitoring wells no farther than 400 feet from the well field. These monitoring wells will be screened in the same zone as the production well. There will be additional wells monitoring the aquifers above and potentially below the ore-bearing aquifer. Sampling of monitoring wells will occur at least twice monthly and no more than 14 days apart in any given month during ISR operations and at least every 60 days during active aquifer restoration. Recovery and monitoring work in conjunction, as a coordinated effluent control system, and has proven effective in early detection of recovery fluids for a number of reasons:

- Close proximity of monitoring wells to well field

- Low flow of production wells
- Cone of depression created from production bleed

The overall effect of the system makes non-detection highly unlikely.

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

- Plugging and Abandonment of historical wells and exploration holes if they pose the potential to impact the control and containment of well field solutions within the project area (see Section 5.7.1.3.3).
- Conducting Mechanical Integrity Tests (MITs) on each well before it is put on line.
- Sampling the monitoring wells located within the overlying and underlying aquifers on a frequent schedule.

These controls work together to prevent and detect production fluid migration. Plugging exploration holes prevents connection of the ore-bearing aquifer to overlying and underlying aquifers. The EPA UIC requirement of MITs assures proper well construction and is the first line of defense for maintaining appropriate pressure without leakage. Sampling the monitor wells will enable early detection of any production solutions should an excursion occur.

Sediment or erosion of existing soils has the potential to lead to a release of undesirable elements in addition to the aforementioned spills. The greatest likely hood of this type of release may occur during the construction phase of the project. Two types of Best Management Practices (BMPs) will be employed to minimize the effects of runoff during precipitation events. One type is erosion prevention practices and the second type is sediment control practices.

Erosion Prevention Practices utilize ground covers that prevent different types of erosion from occurring. Ground covers include but are not limited to:

- Vegetation
- Riprap
- Mulch
- Blankets

Sediment control practices prevent soil particles that are being carried in storm water from leaving the site. These types of controls may consist of:

- Silt fence
- Sediment traps
- Sediment basins
- Vegetative cover

Leaving as much of the vegetation in place for as much of the construction period as possible will reduce the potential for a precipitation event to cause significant erosion and soil loss on-site. Utilizing erosion prevention and sediment controls in combination will prevent sediment loss during a major precipitation event. In addition to the above mentioned controls, engineering design and administrative controls will also minimize and control erosion and runoff. Should a pipeline failure coincide with a precipitation event, there is potential for a release. Relative soil saturation beneath the leak area would be a determining factor to what extent the material would be able to be absorbed. In any event with rapid detection and quick spill response a pipeline failure and migration of solutions due to runoff would be minimal.

5.7.1.3.1 Evaluation of Potential Impacts to Water Supply Wells

During the design of each well field, all nearby water supply wells will be evaluated for the potential to be impacted by ISR operations or the potential to interfere with ISR operations. If needed, this evaluation will also include groundwater modeling. The results of the evaluation will be contained within a well replacement plan described in the hydrogeologic data package for each well field.

At a minimum, all domestic wells within the project area and all stock wells within ¼ mile of well fields will be removed from private use. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well.

The well owner will be notified in writing prior to removing any well from private use. Powertech (USA) will work with the well owner to determine whether a replacement well or alternate water supply is needed.

Section 5.7.8 describes the operational groundwater monitoring plan that will be used to assess potential impacts to domestic and livestock wells. The monitor well ring will provide advance warning before any wells outside the ring have potential to be impacted. If routine monitoring of a water supply well indicates diminished water quantity or quality, the well owner will be notified in writing and the well will be removed from use. Powertech (USA) will work with the well owner to determine if well replacement is necessary. Well replacement procedures are described below. The monitoring and well replacement or abandonment procedures to be implemented by Powertech (USA) will assure that there will be no effects on anyone or any water well outside the monitor well ring.

The following provides details on specific wells and describes procedures Powertech (USA) will utilize to protect public health.

Wells 12, 51, 510, 619, 620 and 650 are used for stock watering and are located within the project area. Powertech (USA) has verified the locations of the wells; however, not all completion details are currently known. A down-hole camera or other tool will be used to determine well construction details in all of the wells. These stock wells are more than ¼ mile from currently identified potential well field areas. They will be evaluated during the course of well field development and delineation drilling for the potential to be adversely affected by or to adversely affect ISR operations.

Wells 14 and 51 are both used to supply water for livestock. Well 14 is located approximately ¾ mile northwest of the proposed Burdock Well Field I and is completed in the Lower Fall River Formation. Well 51 is completed in the Chilson and is located outside of the project area, approximately 1 mile west of the proposed Burdock Well Field I.

Well 16 is a domestic well that provides water to a seasonal residence. The well is located within a proposed well field and will be removed from private use prior to operations. Since the construction details of the well are unknown, Powertech (USA) has implemented an investigation plan with the landowner to enter the well with a down-hole camera or other tool to determine construction details. Based on well construction the well will either be used as a monitor well or plugged and abandoned. Powertech (USA) has drilled a replacement well into the Unkpapa for well 16.

A field investigation of the location designated as well 605 showed only a vertical pipe discharging to a livestock watering tank. Powertech (USA) determined that the vertical pipe is not actually a well but the end of an underground pipeline supplied from well 668 by artesian pressure.

Well 609 is an historical monitor well. According to TVA documents, this well is completed at a depth of 1,000 ft (verified by Powertech (USA)) and screened from 903 to 966 ft across the lower Chilson. Since the well is located approximately 0.4 mile from a proposed well field, it will be evaluated as part of the well field design. The evaluation will determine if the well has the potential to be adversely affected or to adversely affect ISR operations. If it is determined that the well has potential to adversely affect ISR operations, the well will be plugged and abandoned or otherwise mitigated.

Well 618 is located within ¼ mile of a proposed well field and occasionally used for livestock watering purposes. The exact construction details of the well are unknown; therefore, prior to well field design Powertech (USA) will conduct an investigation of the well using a down-hole tool to determine the well depth and screened interval. Due to its proximity to a proposed well field, the well will be removed from private use.

Well 628 is located approximately ¾ mile from the nearest proposed well field and is used for occasional livestock watering. Although complete construction details of the well are currently unknown, Powertech (USA) has determined that the total well depth is 520 feet, and groundwater levels suggest that the well is screened in the upper Fall River Formation. Prior to well field design, an additional investigation of the well will be completed using a down-hole camera or other tool to determine the screened interval. If it is determined that the well has potential to adversely affect or be adversely affected by ISR operations or if routine monitoring indicates changes in water quality, the well will be removed from private use.

Well 637 is an historical monitor well located within a proposed well field. A field investigation determined that the well consists of a 2-inch steel casing, although other construction details are unknown. Prior to well field design a down-hole tool will be utilized to determine the screened interval and total depth. During well field design well 637 will be evaluated to determine if the well has the potential to be adversely affected or to adversely affect ISR operations. If it is determined that the well has potential to adversely affect ISR operations, the well will be plugged and abandoned or otherwise mitigated.

Well 668 is located within a proposed well field area. The well was installed by TVA as an aquifer pump test well for hydrogeologic investigations and is currently used for livestock. According to TVA documents, the well has a total depth of 574 feet and is screened across the Chilson and Fall River. This was recently verified by Powertech.

5.7.1.3.2 Wells to Be Removed from Use

All existing domestic wells within the project area will be removed from private use prior to ISR operations, including wells 13, 16, 40, 42, 43, 703, 704, 4002. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the wells for monitoring or plug and abandon the wells.

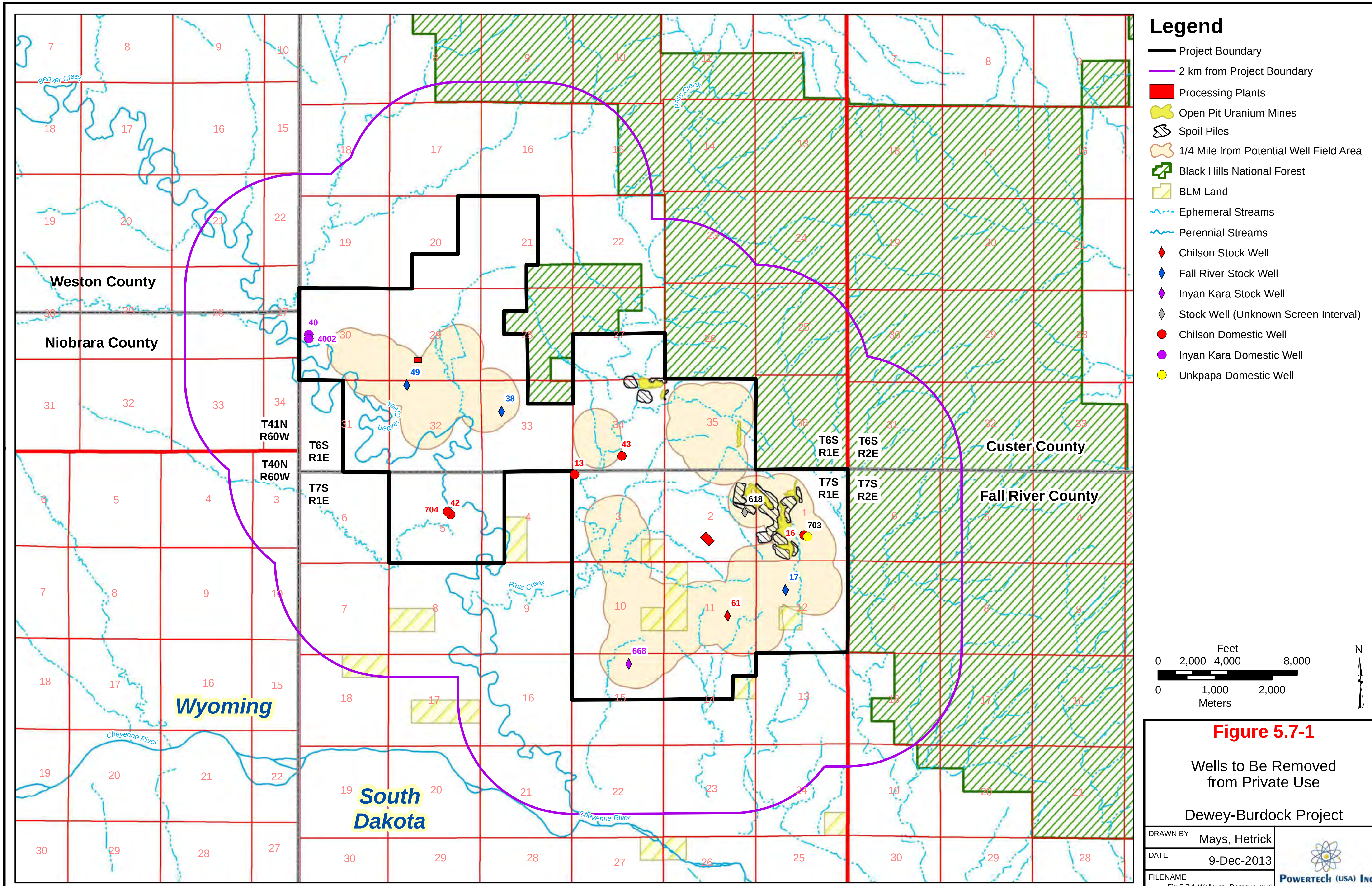
Stock wells within the project area will be evaluated as potential well fields are designed. At a minimum all stock wells that are within ¼ mile of any well field will be removed from private use prior to operation of that well field. In addition, stock wells that could be adversely affected by or could adversely affect ISR operations will be removed from private use. The stock wells currently anticipated to be removed from private use include wells 17, 38, 49, 61, 618, and 668. Currently, well 628 is not expected to be removed from private use as it is more than ¼ mile from any potential well field areas. Additional delineation drilling after license issuance may change the extent of the potential well field areas or provide additional well field areas within the project area. Therefore, each potential well field will be evaluated with regard to existing nearby stock water use and an evaluation will be included within the well field hydrogeologic data package for each well field.

Figure 5.7-1 shows the location of all domestic and stock wells currently anticipated to be removed from private use. Wells 20 and 135 are not within 2 km of the project boundary and will not be adversely affected by ISR operations.

Prior to ISR operations, Powertech (USA) will assume control of all wells within the project area boundary listed as “monitor” in Table 1 of Appendix 2.2-A. These will be secured at the well heads to prevent unauthorized use.

5.7.1.3.3 Water Supply Well Replacement Procedures

Replacement wells will be located an appropriate distance from the well fields and will target an aquifer outside of the ore zone that provides water in a quantity equal to that of the original well and of a quality which is suitable for the same uses as the original well, subject to the lease agreement and South Dakota State water law.


Legend
Project Boundary
2 km from Project Boundary
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Chilson Stock Well
Fall River Stock Well
Inyan Kara Stock Well
Stock Well (Unknown Screen Interval)
Chilson Domestic Well
Inyan Kara Domestic Well
Unkpapa Domestic Well
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
Beaver Creek
Pass Creek
Cheyenne River
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 5.7-1
Wells to Be Removed from Private Use
Dewey-Burdock Project
DRAWN BY Mays, Hetrick
DATE 9-Dec-2013
FILENAME Fig 5.7-1 Wells_to_Remove.mxd
Powertech (USA) Inc.

Lease agreements for the entire project area currently allow Powertech (USA) to remove and replace the water supply wells as needed. The following is an excerpt from the lease agreements with each landowner. (Note: all lease agreements formerly held by Denver Uranium have been assigned to Powertech (USA).)

> *"DENVER URANIUM shall compensate LESSOR for water wells owned by LESSOR at the execution of this lease, as follows: Any such water which falls within an area to be mined by DENVER URANIUM, shall be removed from LESSOR's use. Prior to removal, DENVER URANIUM shall arrange for the drilling of a replacement water well or wells, outside of the mining area, in locations mutually agreed upon between LESSOR and DENVER URANIUM, as may be necessary to provide water in a quantity equal to the original well and of a quality which is suitable for all uses the original water well served at the time such well was removed from LESSOR's use."*

An example of a replacement well is provided in Figure 5.7-1a, which shows use of the project Madison well to supply water by pipeline to local stock tanks.

5.7.1.3.4 Exploration Hole Mitigation Procedures

As with any other site proposed for ISR uranium recovery, historical exploration holes and wells are present within the project area. Powertech (USA) will use the best available information and best professional practices to locate boreholes or wells in the vicinity of potential well field areas, including historical records, use of color infrared imagery, field investigations, and potentiometric surface evaluation and pump testing conducted for each well field as part of the development of complete well field hydrogeologic packages. As with other ISR facilities, Powertech (USA) anticipates that some unplugged holes or wells may be encountered during well field design. Consistent with standard industry operating practices and experience, the following describes the procedures Powertech (USA) will implement to detect and mitigate any unplugged holes or wells that have the potential to impact the control and containment of well field solutions.

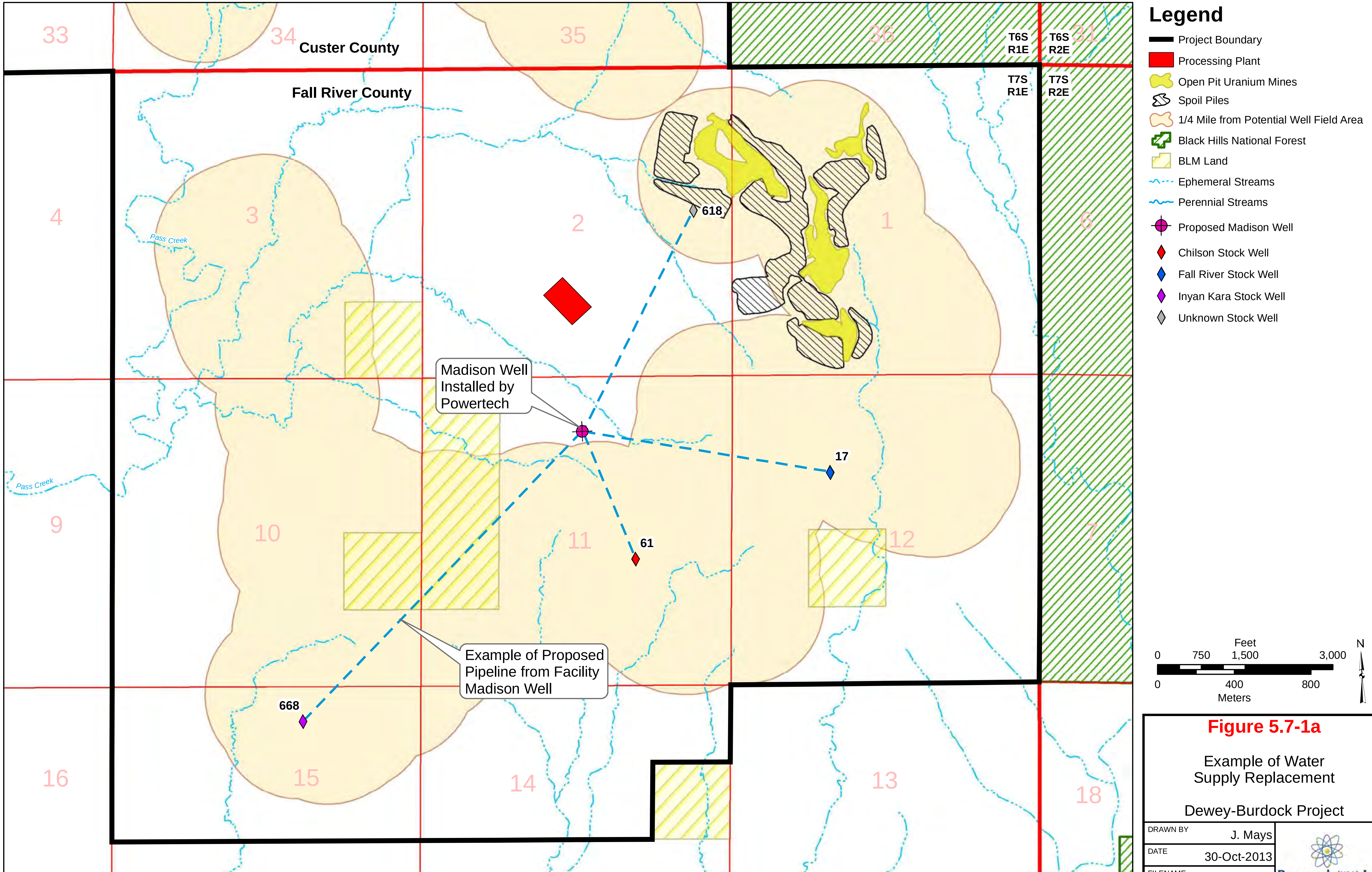


Figure 5.7-1a

Example of Water Supply Replacement

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	30-Oct-2013
FILENAME	Fig 5.7-1a Wells-ExH2OReplace.mxd

POWERTECH (USA) INC.

Powertech (USA) commits to properly plugging and abandoning or mitigating any of the following should they pose the potential to impact the control and containment of well field solutions within the project area:

1) Historical wells and exploration holes
2) Holes drilled by Powertech (USA) for the purposes of delineation and exploration
3) Any wells failing mechanical integrity testing (MIT) including those installed by Powertech (USA) and those installed before Powertech (USA)

Powertech (USA) will attempt to locate with best professional practices any presently unknown boreholes or wells in the vicinity of every potential well field. Historical records will be used to determine the presence of previous boreholes and wells. Pump testing conducted as part of routine well field hydrogeologic package development will use an array of monitor wells designed to detect and locate any unknown boreholes or wells. The pump testing also will be designed to provide sufficient hydrogeologic data to demonstrate that the well field design and monitoring systems are sufficient to control and detect any potential excursions. Details of the pump testing program are provided in Section 3.1.3.2.

Should any hole or well at or near potential well fields be suspected of being improperly plugged and abandoned, Powertech (USA) will use best professional practices to precisely locate and re-enter the suspected problem hole with a drill rig or tremie pipe. Powertech (USA) will evaluate mitigation alternatives including plugging and abandoning the hole or well with grout as described below. Powertech (USA) may enter the well with logging equipment prior to plugging and abandoning the well to confirm that the well poses a potential problem.

It is not surprising that there is little evidence of unplugged drill holes in the project area, even though there is a long history of mineral exploration in this area and much of this occurred prior to enactment of modern laws and regulations governing plugging and abandoning drill holes. This is because of the well-known natural tendency of drill holes to seal themselves by collapsing, caving and swelling of the formations through which the holes are drilled. During exploration, drill holes must be logged promptly after drilling in order to minimize the risk of losing logging tools or losing the ability to access the full depth of the holes due to the processes described above. During the pump testing that will be done as part of the preparation of the hydrogeologic package for each well field, special attention will be paid to known or suspected locations of exploration holes to detect evidence of interaquifer communication that might be the result of unplugged drill holes.

Plugging and Abandonment Procedures

Powertech (USA)'s standard operating procedures will include plugging and abandoning all boreholes completed during the process of exploration and delineation drilling. Any wells installed by Powertech (USA) which fail MIT and cannot be repaired also will be plugged and abandoned.

Powertech (USA) will plug all wells or exploration holes with bentonite or cement grout. The weight and composition of the cement will be sufficient to control artesian conditions and meet the well abandonment standards of the State of South Dakota, including Chapter 74:11:08 (Capping, Sealing, and Plugging Exploration Test Holes) and Chapter 74:02:04:67 (Requirements for Plugging Wells or Test Holes Completed into Confined Aquifers or Encountering More than One Aquifer) of the South Dakota Administrative Rules. Cementing will be completed from total depth to surface using a drill pipe. Records will be kept of each well or exploration hole cemented including at a minimum the following information:

- well or hole ID, total depth, and location
- driller, company, or person doing the cementing work
- total volume of cement placed down hole
- viscosity and density of the slurry used

Powertech (USA) will remove surface casing and set a cement plug to a depth 6 ft below the ground surface on each well or borehole plugged and abandoned.

Mitigation and Avoidance

Boreholes or wells which may potentially impact control of well field operations will be evaluated using pump test data and groundwater modeling. Should it be determined that it is not possible to mitigate potential adverse impacts from any unplugged borehole or well that is discovered, the affected well field will be designed to minimize any potential impacts.

The monitoring system will be designed to demonstrate well field control. This may include monitor wells in addition to those provided for normal well field operations. All of these details will be included in the well field hydrogeologic data package that will be prepared for each well field and reviewed by Powertech (USA)'s SERP prior to operation of that well field (see Section 3.1.3.3).

5.7.1.4 Contaminated Equipment

Solid wastes generated by this project that are contaminated with process related material consist of materials such as rags, contaminated personal protective equipment, trash, packing material, worn or replaced parts from equipment, piping, sediments removed from process pumps and vessels . Radioactive solid waste that has a contamination level requiring controlled disposal will be isolated in drums or other suitable containers and disposed in a NRC licensed facility or as otherwise approved by the NRC. The combined operations at the SF and CPP will generate between approximately 100 to 300 yd^3 of radioactive contaminated waste each year. During final decommissioning of the CPP facilities and SFs, the volume of solid waste will increase.

5.7.2 External Radiation Monitoring Program

Powertech (USA) will monitor external radiation exposure at the Dewey-Burdock facility. The monitoring will be done in three ways: continuous measurements at fixed locations, employee monitoring, and period work area surveys. The external radiation monitoring program will be

consistent with the recommendation contained in NRC Regulatory Guide 8.30 *"Health Physics Surveys in Uranium Recovery Facilities."*

5.7.2.1 Fixed Location Monitoring

External radiation exposure measurements will be made in the locations shown in Figures 5.7-2 through 5.7-5. The designated monitoring locations are measurement locations, not fixed radiation monitoring points. The measurements at these locations will be made quarterly using radiation survey meters.

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5.7.2.2 Employee Monitoring

Pursuant to 10 CFR 20.1502, employees working at the facility will be monitored for external radiation exposure if they have the potential to receive 10 percent of an applicable limit in a year. OSL dosimeters will be utilized quarterly for assessing the external dose for individuals who may potentially exceed 10 percent of the annual occupational limit (10 CFR 20.1201(a)). Powertech (USA) may monitor other workers, although not required, for occupational exposures during the first year of operations, or any other period deemed necessary, to ensure that all workers are receiving less than 10 percent of the 5 rem annual limit. After the periodic evaluation, monitoring may be reduced or eliminated at some locations. This decision will be at the discretion of the RSO and the SERP. The number and category (based on the organizational chart shown on Figure 5.1.2) of personnel that will be included in the external radiation monitoring program are shown in Table 5.7.2-1.

Table 5.7.2-1: Number and Category of Personnel Included in the External Radiation Monitoring Program

Category	Number of Employees*
Construction Superintendent	31
Production Superintendent	43
Radiation Safety Officer	9
Total	83

*Includes category supervisor and all personnel working under each category supervisor

Monitoring requirements will be determined in accordance with guidance found in NRC Regulatory Guide 8.34.

The applicable adult worker radiation dose limits are as follows:

- 5 rem deep-dose equivalent (DDE)
- 15 rems lens dose equivalent (LDE)
- 50 rems shallow-dose equivalent to the skin (SDE)
- 50 rems shallow-dose equivalent to any extremity

Applicable limits for minors working at the facility are 10 percent of the adult limits listed above.

Applicable limits for declared pregnant workers are the same as adult workers with the exception of the DDE with is 10 percent of the adult limit for the period of gestation.

Multiple dosimeters may be issued to employees that have the potential to receive two or more of the doses listed above. The dosimeters will have a sensitivity of 1 mrem and will be issued by a company currently holding personal dosimeter accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). The dosimeters will be exchanged monthly for worker with declared pregnancies and quarterly for all other radiation workers.

All external doses received by monitored personnel above 10 percent of the above limits will be reported on NRC Form 5 or in a format which contains all the information listed on NRC Form 5.

5.7.2.2.1 Employee Monitoring in High Radiation Areas

A high radiation area is defined in 10 CFR Part 20 as "an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates." The existence of such a high radiation area within an ISR facility is highly unlikely due to the nature of the radioactive materials involved. However, in the unlikely event an individual had to enter a high radiation area, the work will be conducted under a Radiation Work Permit, which characterizes the radiological hazards and identifies controls, both engineering and administrative, and PPE to keep radiation doses to levels that are ALARA. The individual will be monitored with a personal monitoring device and equipped with a calibrated rate meter and appropriate detector. Any work performed within the area will be limited and performed in such a manner as to maintain doses to levels that are ALARA. In accordance with Subpart G §20.1601, Powertech (USA) will have qualified staff (e.g., RSO, RSTs) present and prepared to implement and utilize monitoring devices and the controls deemed applicable to the specific circumstances and area in order to control access and exposure.

5.7.2.3 External Radiation Surveys

Shortly after the facility becomes operational, at least 20 gamma radiation measurements will be taken in order to characterize the radiation levels at the facility, as stated in RG 8.30. The locations where these measurements will be performed are depicted on Figures 5.7-2 through 5.7-5. Based on these measurements, areas where a person may receive a dose of 5 mrem in 1 hour at 30 cm (1 foot) from a radiation source or radiation-emitting surface will be posted as a "Radiation Area" as required in 10 CFR 20.1902(a). For areas with radiation levels less than those defined for a radiation area, follow-up measurements will be performed semiannually to evaluate potential impacts of changing process conditions on facility radiation levels.

Areas posted as "radiation areas" will be investigated to determine the source of radiation and will be surveyed for gamma radiation on a quarterly basis as described in RG 8.30. Methods to reduce radiation levels using engineering controls, process adjustments, or maintenance practices will be evaluated once the source of radiation is determined

The typical gamma exposure rates during operation are expected to range from background up to 1,000 μR per hour. The gamma dose rates will be estimated by assuming 1 μR per hour is equivalent to 1 μrem per hour. There may be rare occasions where the gamma dose rate may approach 5 mrem per hour. The instrument that will be used for most gamma surveys is the Ludlum 19 or equivalent. The typical operating specifications for this instrument are shown in Table 5.7.2-2. This instrument can measure dose rates up to 5 mrem/hr. If gamma dose rates larger than 5 mrem/hr are evident, a Ludlum model 44-38 or equivalent type of detector coupled with an appropriate rate meter will be used. The typical operating specifications for the Ludlum model 44-38 are shown in Table 5.7.2-2. The Ludlum 44-38 can also be used when performing beta surveys where appropriate in and around the process area. Both instruments will be on site and available for use by properly trained staff during operations.

Table 5.7.2-2: Ludlum 19 and Ludlum 44-38 Operating Specifications.

Instrument Model	Instrument Type	Radiation Type	Measurement Range	Sensitivity
Ludlum Model 19	Sodium Iodide (Tl) scintillometer (1 in x 1 in)	Gamma	0 – 5,000 μR/hr	175 cpm per μR/hr (Cs-137)
Ludlum Model 44-38	Geiger-Mueller (GM), halogen quenched	Gamma and beta	Up to 50 mR/hr	1,200 cpm per mR/hr (Cs-137) with window closed

The instrumentation will be calibrated according to the manufacturer's instructions or at least once a year. Operational checks on the instruments will be performed before each daily use. The instruments will be operated according to manufacturer's recommendation.

Since yellowcake will be generated at the facility, there is a potential hazard from external beta radiation. Specifically, operations requiring direct handling of aged yellowcake may lead to significant exposures to the skin. Therefore, a beta survey will be conducted at or near surfaces for each operation requiring direct handling of yellowcake. A beta survey will also be conducted when the equipment or operating procedures are changed in a way that may affect the exposure of the worker to beta radiation. These surveys will also be used in determining the level of personal protective equipment (PPE) required for the operations.

The instrumentation to be used in the beta surveys will be portable, have a sufficient efficiency for detecting beta radiation, and have a low efficiency for detecting gamma radiation. An example is a Ludlum Model 44-9 Pancake G-M Detector coupled with an appropriate ratemeter/scaler.

Beta doses will be determined using one of two ways. One method uses the information acquired during the beta radiation surveys. Average beta radiation fluence rates can be estimated, assuming all net counts are beta radiation from the yellowcake. The estimated average particle fluence rates, along with the amount of time spent on each operation by each worker and the average energy of beta radiation emitted from yellowcake can be used to determine the amount of radiation dose to the skin of the workers from beta radiation. The other method to determine beta radiation doses involve using Figures 1 and 2 from RG 8.30.

5.7.2.4 Action Levels for Gamma Dose Rates and Dosimeter Results

Action levels for gamma radiation dose rates will be as follows:

1) Areas with gamma exposure rate measurements above 0.25 mR/hr will require individuals working in and around the area to wear personal dosimeters. An evaluation regarding the cause of the exposure rate will be conducted and steps will be taken to keep exposure rates ALARA.
2) Areas with gamma exposure rate measurements above 5 mR/hr will be posted as Radiation Areas. An evaluation regarding the cause of the exposure rate will be conducted and steps will be taken to reduce the exposure rate.

In addition, once typical operational gamma dose rate levels have been established, additional administrative action levels may be established as deemed appropriate by the RSO and as reviewed by the SERP.

For dosimeter results, the following action levels will apply:

1) Measured individual worker external whole body deep radiation doses above 125 mrem per calendar quarter or 500 mrem per calendar year will result in investigations as to the cause of the dosimeter result, and steps will be taken to keep radiation doses ALARA.
2) Measured individual worker shallow-doses (skin) above 1,250 mrem per calendar quarter or 5,000 mrem per calendar year will also result in investigations as to cause and procedures to mitigate.
3) Measured individual worker external whole body radiation deep doses above 312 mrem per calendar quarter or 1,250 mrem per calendar year will result in work restrictions for the affected workers until an investigation has determined that cumulative internal and external EDEs for the year are unlikely to exceed 5 rem, and that the doses are ALARA.

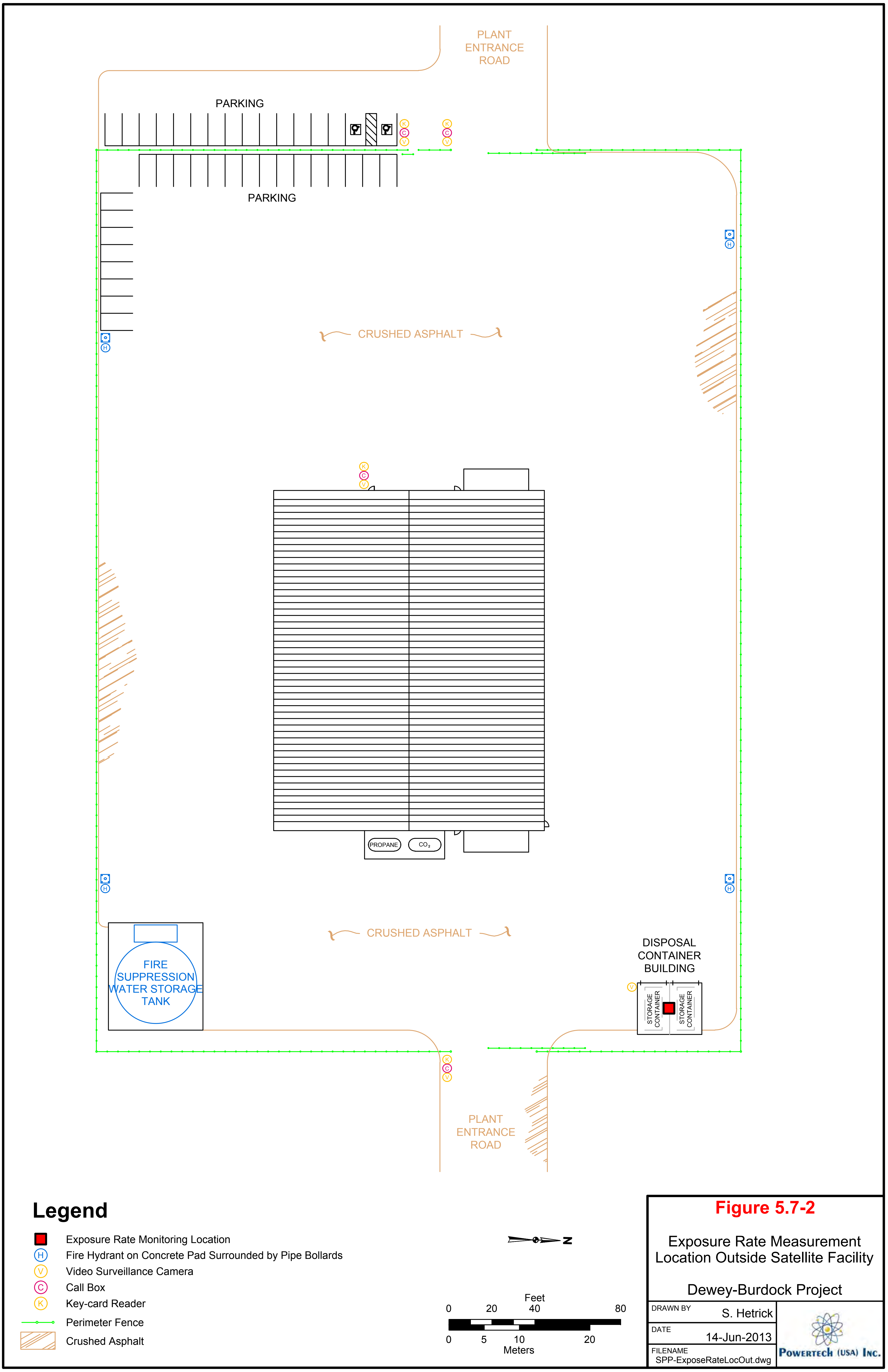
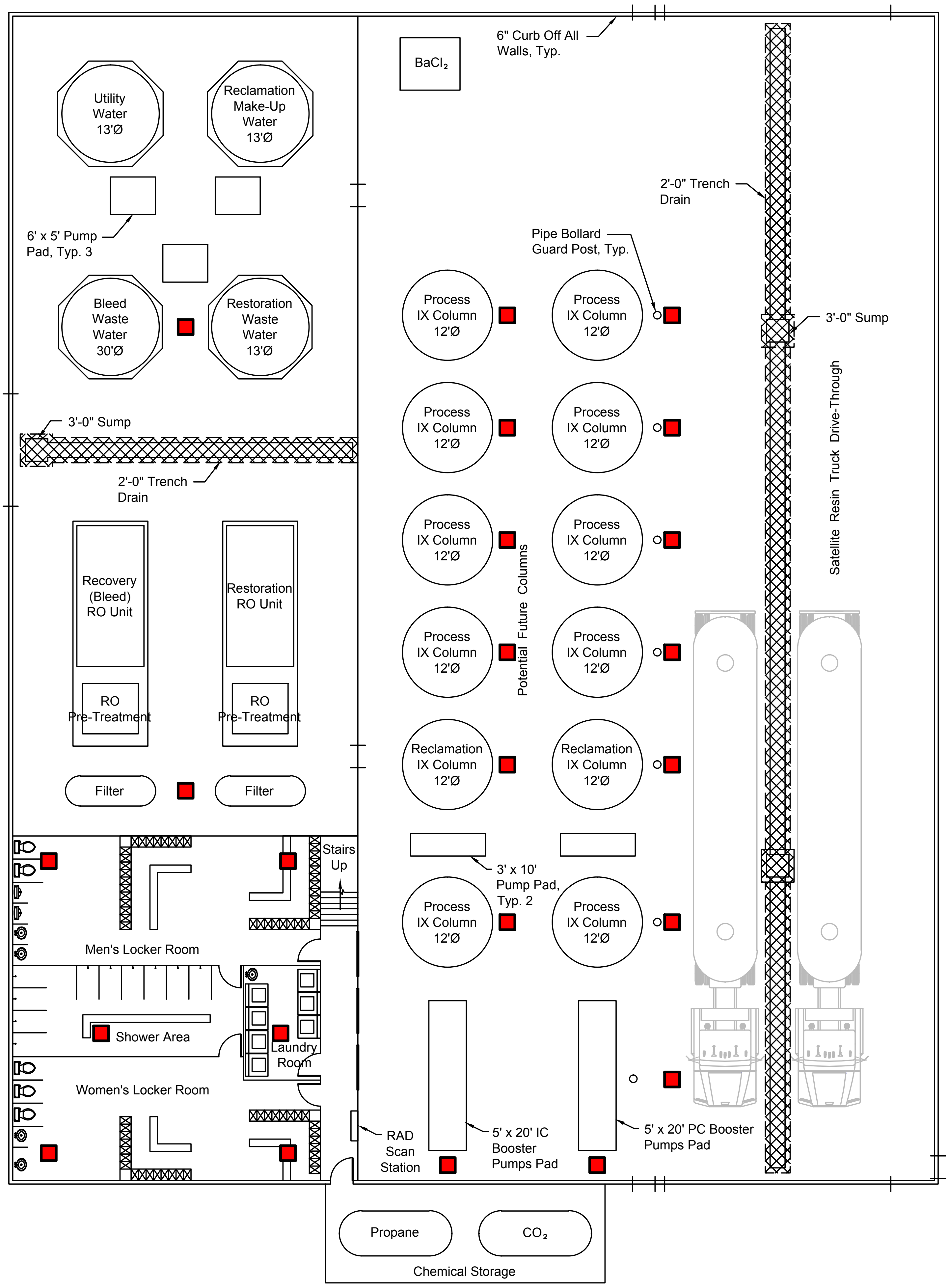


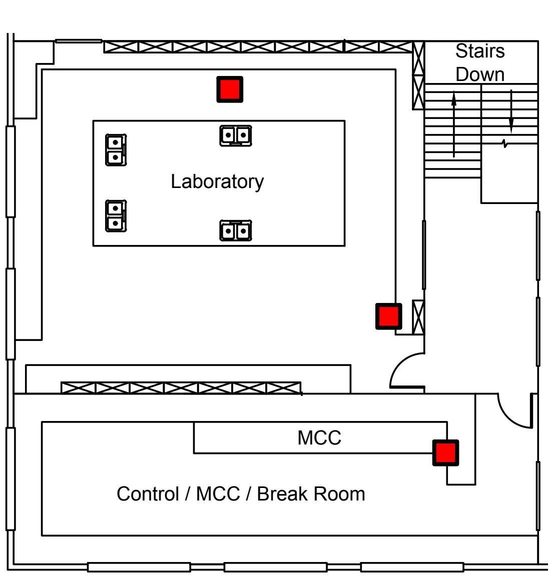
Figure 5.7-2

Exposure Rate Measurement Location Outside Satellite Facility

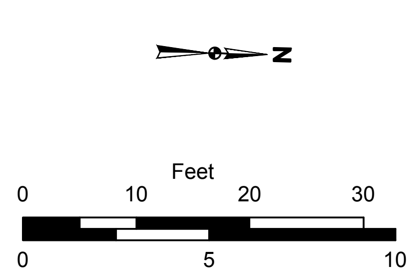
Dewey-Burdock Project



Ground Floor Plan



Second Floor Plan



Legend

■ Exposure Rate Monitoring Location

Figure 5.7-3

Exposure Rate Measurement Locations Inside Satellite Facility

Dewey-Burdock Project

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DATE	14-Jun-2013
FILENAME	SPP-RadDecayProdIn.dwg

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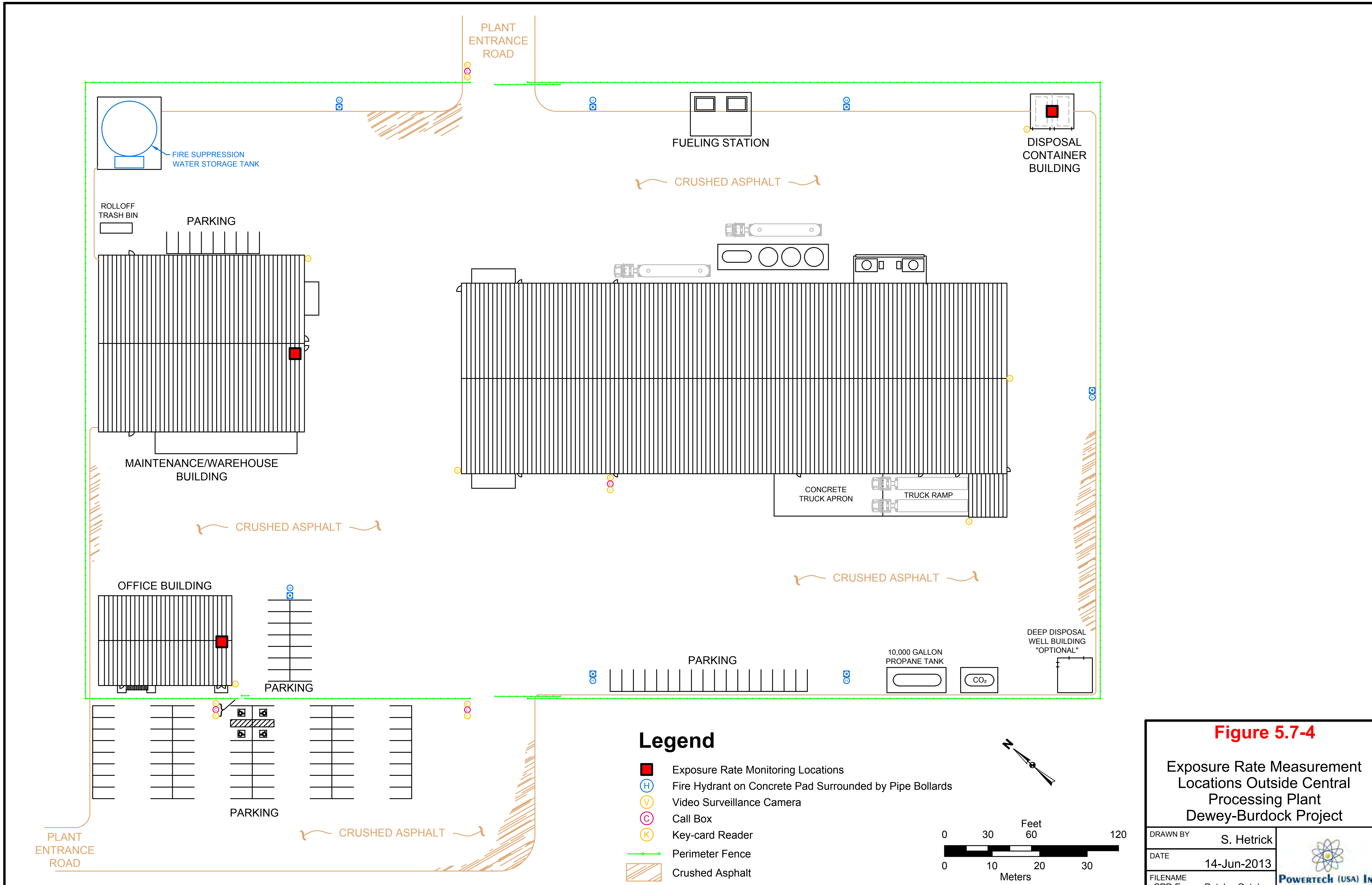

Figure 5.7-4

Exposure Rate Measurement Locations Outside Central Processing Plant Dewey-Burdock Project

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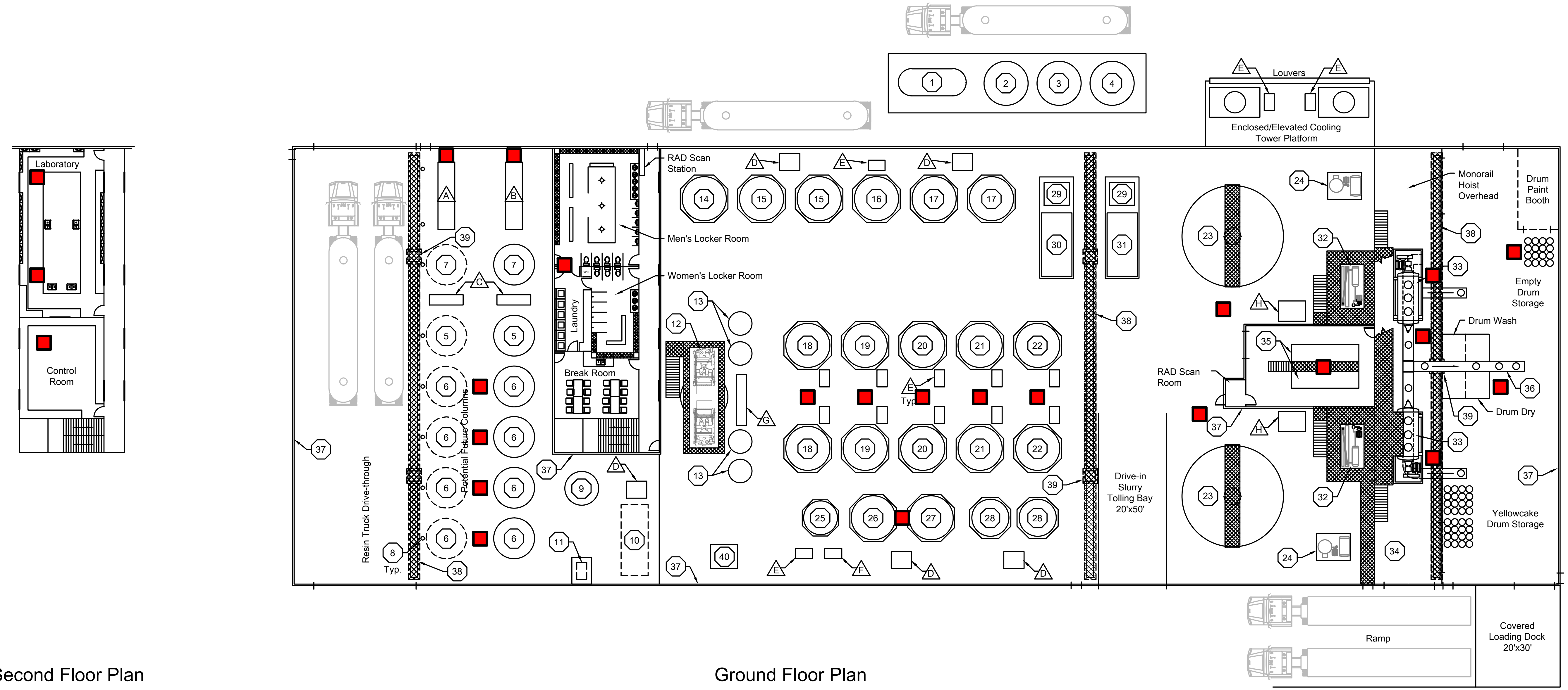
DATE	14-Jun-2013
FILENAME	CPP-ExposeRateLocOut.dwg

Powertech (USA) Inc.



Second Floor Plan

Ground Floor Plan

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'Ø
6. Process IX Column 12'Ø
7. Bleed IX Column 12'Ø
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'Ø
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'Ø
14. Reclamation Make-up Water 13'Ø
15. NaCl 13'Ø
16. Na_2CO_3 13'Ø
17. Utility Water 13'Ø
18. Fresh Eluant 13'Ø
19. Lean Eluant 13'Ø
20. Intermediate Eluant 13'Ø
21. Rich Eluant 13'Ø
22. Precipitation 13'Ø
23. 30'Ø Thickener, 5'Ø Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'Ø
26. High TDS Wastewater Tank 13'Ø
27. Low TDS Wastewater Tank 13'Ø
28. Solids Removal Tank 11'Ø
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A — 5'x20' - PC Booster Pumps
- B — 5'x20' - IC Booster Pumps
- C — 3'x10' - Pump
- D — 6'x5' - Pump
- E — 3'x5' - Pump
- F — 3'x5' - Disinfectant
- G — 3'x15' - Pump
- H — 6'x8' - Pump

N

Feet: 0, 15, 30, 60
Meters: 0, 5, 10, 20

Legend

■ Exposure Rate Monitoring Locations

Figure 5.7-5

Exposure Rate Measurement Locations Inside Central Processing Plant Dewey-Burdock Project

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FILENAME	CPP-ExposeRateLocln.dwg

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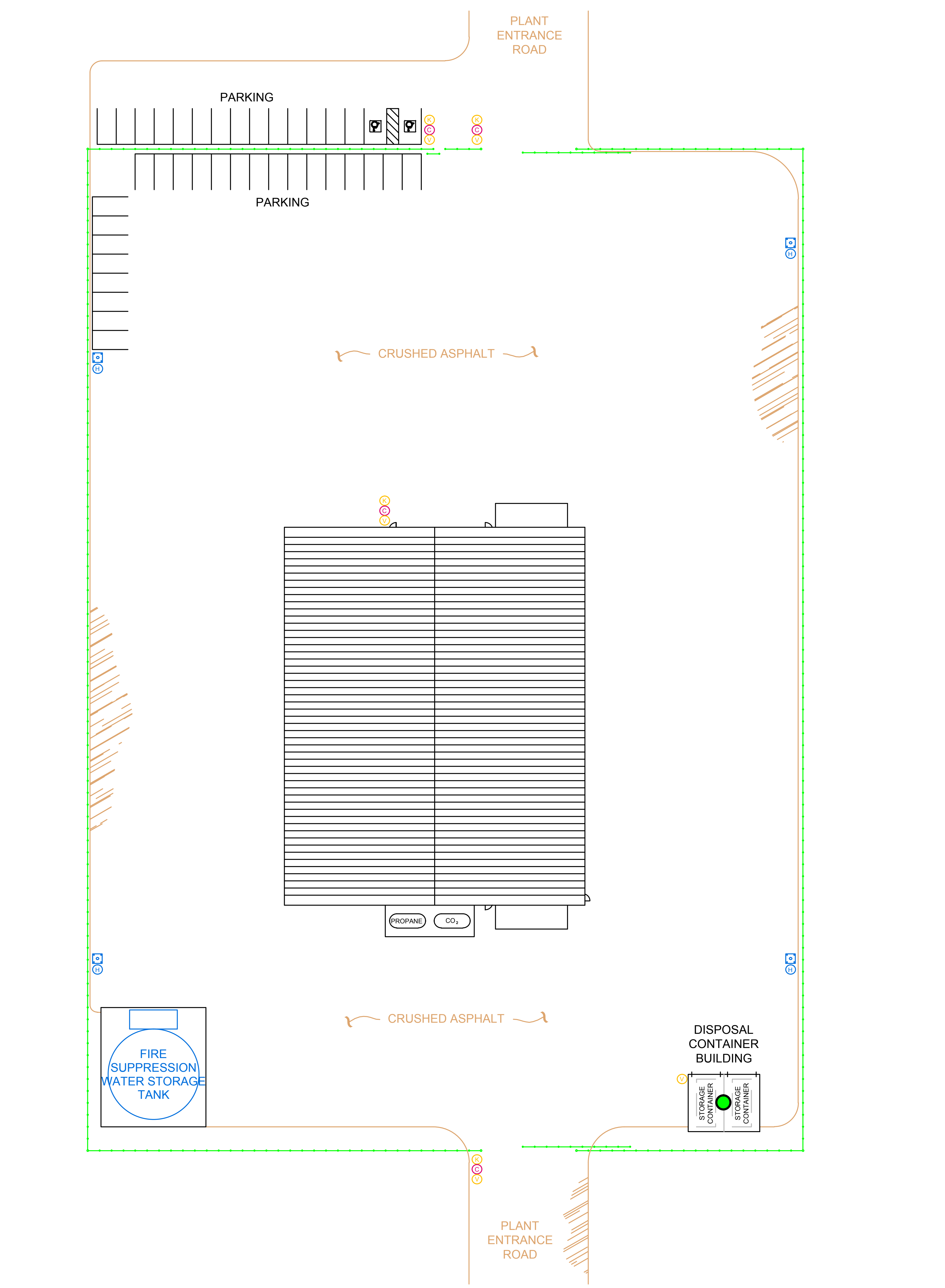
5.7.3 Airborne Radiation Monitoring Program

Powertech (USA) will conduct an airborne radiation monitoring program at the project facility which is consistent with the recommendations contained in RG 8.30. The facility will not process ore. However, the facility will precipitate, dry (at low temperatures), and package yellowcake. Therefore, the monitoring program will consist of monitoring radon decay products, as well as airborne particulate monitoring. During the first year of operation an extensive air particulate program will be implemented in order to evaluate and determine area concentrations of key particulates to which workers may be exposed.

5.7.3.1 Monitoring of Radon and Radon Decay Products

According to RG 8.30, measurements of radon decay products are a better measure for worker dose than measurements of radon. Therefore, measurements of radon decay products will be made in the facility.

Working level (WL) measurements for radon decay products will be made on a monthly basis in areas where radon decay product concentrations are likely to exceed the LLD of 0.03 WL as described in RG 8.30. Figures 5.7-6 to 5.7-9 present the monitoring locations where radon decay products could possibly exceed 0.03 WL. Additionally, areas where the radon decay product concentration exceeds 0.08 WL, as indicated by the monthly WL measurements, will be measured for radon decay products on a weekly basis. For these areas, investigations will be conducted to determine the source and corrective action will be taken if determined necessary by the RSO. If four consecutive weekly measurements in an area show the concentration of radon decay products to be at or below 0.08 WL, then the frequency of measurements in that area will return to monthly. Areas proximal to radon sources that do not exhibit radon decay product concentrations above 0.03 WL, as indicated by monthly WL measurements, will have WL measurement frequency reduced to quarterly. The time, date, and state of operation of the equipment in the vicinity of the measurement will be recorded. Areas that do not exhibit radon decay product concentrations above 0.03 WL but are proximal to radon sources will be evaluated on a quarterly basis. In addition, areas where workers routinely work and may be exposed to radon decay products will be evaluated at the discretion of the RSO.



Legend

- Radon Decay Product Monitoring Locations
- (H) Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- (V) Video Surveillance Camera
- (C) Call Box
- (K) Key-card Reader
- Perimeter Fence
- Crushed Asphalt

Figure 5.7-6

Locations of Radon Decay Product Monitoring Sites Outside Satellite Facility Dewey-Burdock Project

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DATE	14-Jun-2013
FILENAME	SPP-RadDecayProdOut.dwg

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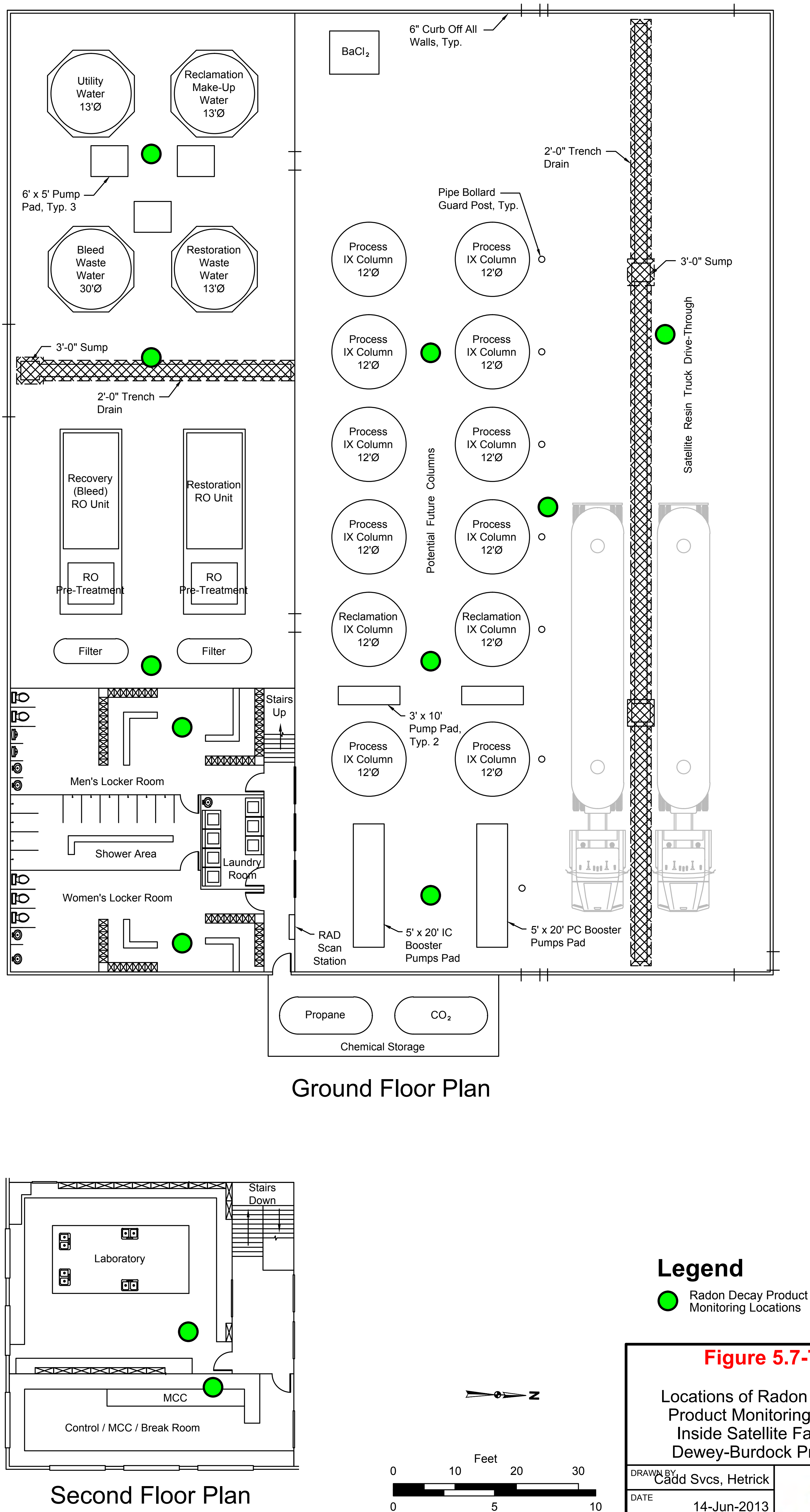

Figure 5.7-7

Locations of Radon Decay Product Monitoring Sites Inside Satellite Facility Dewey-Burdock Project

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DATE 14-Jun-2013
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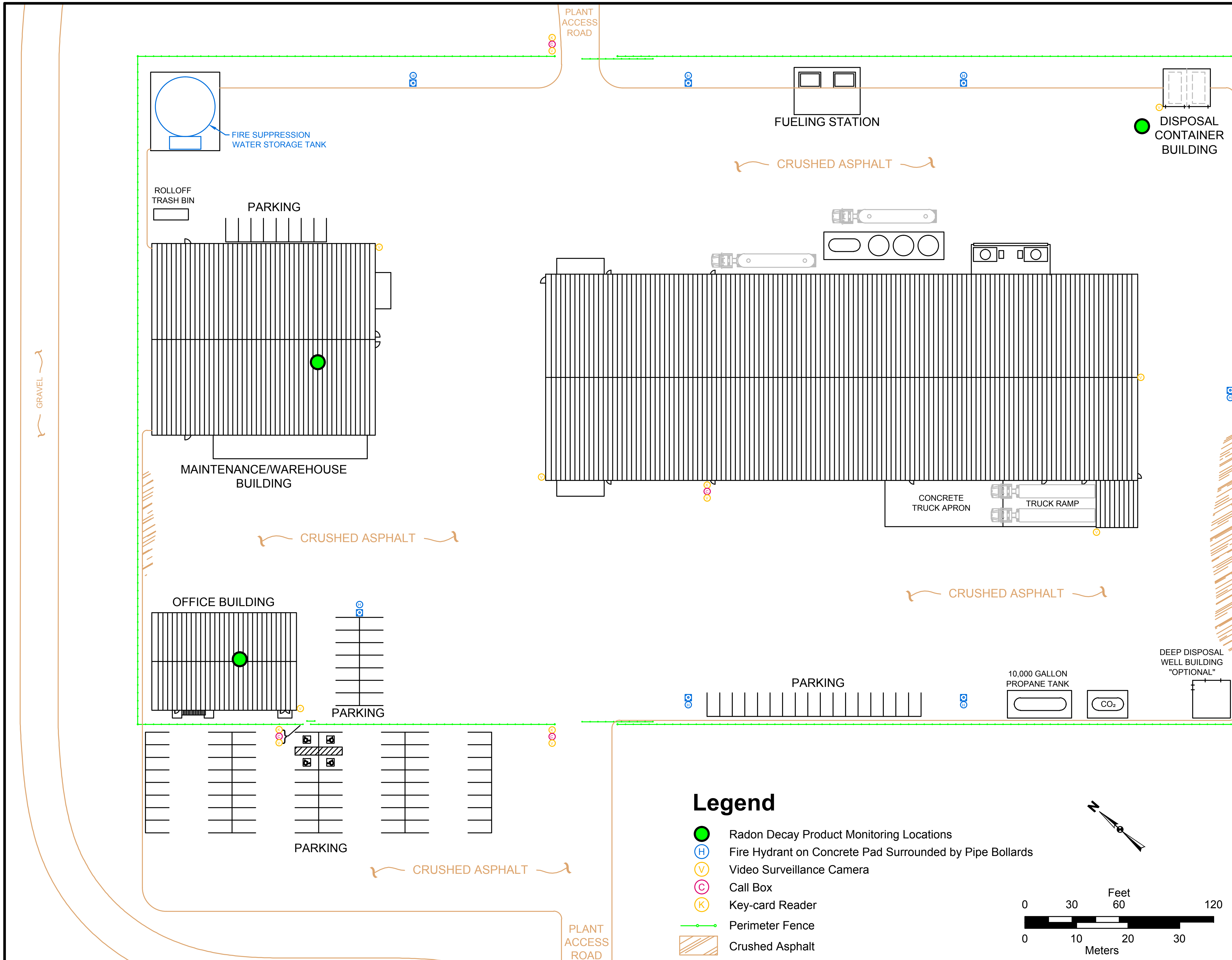

Figure 5.7-8

Locations of Radon Decay Product Monitoring Sites Outside Central Processing Facility Dewey-Burdock Project

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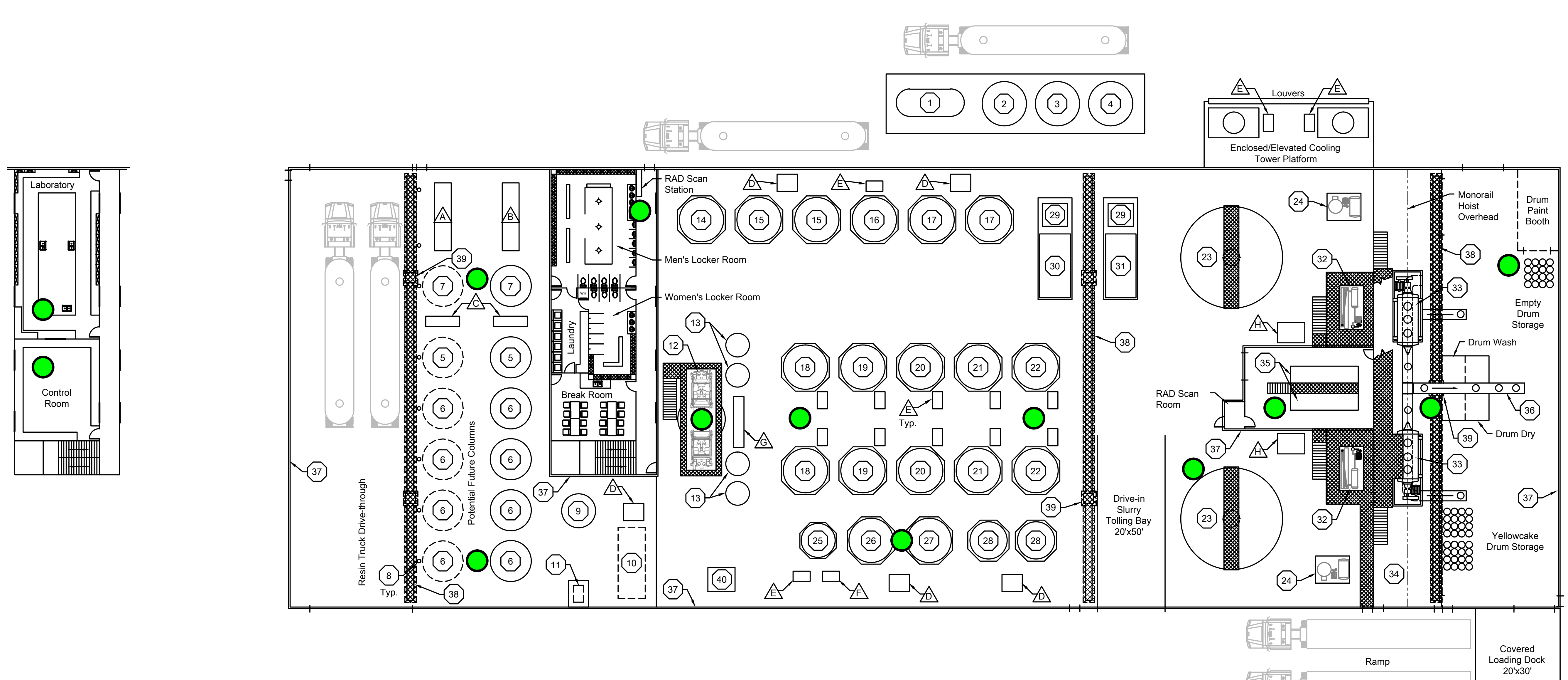

Second Floor Plan

Ground Floor Plan

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'⌀
6. Process IX Column 12'⌀
7. Bleed IX Column 12'⌀
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'⌀
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'⌀
14. Reclamation Make-up Water 13'⌀
15. NaCl 13'⌀
16. Na_2CO_3 13'⌀
17. Utility Water 13'⌀
18. Fresh Eluant 13'⌀
19. Lean Eluant 13'⌀
20. Intermediate Eluant 13'⌀
21. Rich Eluant 13'⌀
22. Precipitation 13'⌀
23. 30'⌀ Thickener, 5'⌀ Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'⌀
26. High TDS Wastewater Tank 13'⌀
27. Low TDS Wastewater Tank 13'⌀
28. Solids Removal Tank 11'⌀
29. RO Pre-treatment
30. Recovery RO Unit
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32. Elevated Condenser/Vacuum Pump Skid 7'x13'
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- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump

Feet: 0, 15, 30, 60
Meters: 0, 5, 10, 20

Legend

● Radon Decay Product Monitoring Locations

Figure 5.7-9

Locations of Radon Decay Product Monitoring Sites Inside Central Processing Facility Dewey-Burdock Project

DRAWN BY	Cadd Svcs, Hetrick
DATE	14-Jun-2013
FILENAME	CPP-RadDecayProdIn.dwg

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The measurements will be performed by collecting samples on filter paper with a low-volume air sampler and analyzing the filter paper with an alpha counter using the Modified Kusnetz method described in ANSI N13.8-1973 or an equivalent method. The LLD for radon decay product measurements will be 0.03 WL, as described in RG 8.30, Section 2.3. The air sampler and alpha counter will be calibrated at the manufacturers' suggest time interval.

Airflow patterns in the facilities will be determined based on location of air inlets and exhausts relative to sources of airborne radioactive materials. Neutrally buoyant markers may be used to determine airflow patterns. Airflow patterns for workers will also be observed and monitored. If any worker areas are altered in size or location the air flow will be re-evaluated in those areas. If there is any reason to suspect a change in flow or pattern due to process or equipment changes, the area will be evaluated for airflow pattern changes, and sampling locations will be changed accordingly. Radon decay product samples will be collected at a height of 3 to 6 feet between the source and the area occupied by the workers.

During favorable weather conditions, open doorways and convection vents may change release points and air patterns of radon slightly, but the amount of radon released will remain the same. The concentration of radon gas being emitted under this scenario is expected to be lower compared to radon that is collected in the ventilation system and transported via duct work to an external release point. During plant operation, measurements will be made of radon emission from the plant ventilation system as well as measurements of radon decay products exposure at occupied areas in and around the plant. With these data, analyses of exposure to employees and radon effluent airflow will be conducted to determine if exposure is ALARA. In addition, a radon decay products concentration action level will be established. If the action level is exceeded, an analysis will be conducted to determine if the radon and radon decay products concentration and potential employee exposures are ALARA. Powertech (USA) will implement changes if and when necessary to ensure levels are ALARA. Results of monitoring obtained during initial plant operation will be used to adjust monitoring programs and upgrade ventilation and/or other effluent control equipment as necessary.

Powertech (USA) will implement these monitoring programs to provide sufficient information to demonstrate that radon effluent and worker exposure to radon decay products will be maintained at levels that are ALARA in accordance with the requirements in 10 CFR Part 40, Appendix A, Criterion 8 and 10 CFR § 20.1101(b) and the recommendation in NUREG-1569, Acceptance Criterion 4.1.3(5).

5.7.3.2 Airborne Particulate Monitoring

Since there will be no ore grinding at the facility, no monitoring of airborne uranium ore dust will be necessary. However, airborne yellowcake will be monitored at the facility. The facility will be drying yellowcake under low temperature (approximately 250°F). No stack monitoring will be required for this proposed action. According to the footnotes of 10 CFR 20 Appendix B, yellowcake dried under low temperature should be considered soluble on the following basis. There is no specific reference in 10 CFR 20 that describes hydrogen peroxide precipitated yellowcake as "soluble" for radiation protection purposes. Footnote 3 to 10 CFR 20, Appendix B, Table 1 addresses soluble mixtures of U-238, U-234, and U-235. Regulatory Guide 8.30, Section 2.2 suggests that "yellowcake dried at low temperature, which is predominantly composed of ammonium diuranate, or in the new processes uranyl peroxide, both are more soluble in body fluids than yellowcake dried at higher temperature; and a relatively large fraction is rapidly transferred to kidney tissues." Regulatory Guide 8.30 suggests that uranyl peroxide (i.e., hydrogen peroxide precipitated yellowcake) is soluble. Therefore, Powertech (USA) proposes that footnote 3 to 10 CFR Part 20, Appendix B, Table 1 applies to uranyl peroxide.

Nevertheless, consistent with the NRC staff guidance presented at the November 2009 uranium recovery workshop in Denver, CO, Powertech (USA) will consider hydrogen peroxide precipitated yellowcake dried at < 400° C as a Class W compound for radiation protection purposes until either the solubility class specific to the product produced in the process has been measured or the specific process has been shown to be comparable to similar processes for which the solubility class of the product has been measured.

The limiting factor for health considerations for soluble uranium is chemical toxicity and not radiation dose. According to the footnotes for the radionuclide tables in 10 CFR Part 20 Appendix B, "the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) µCi-hr/ml, where SA is the specific activity of the uranium inhaled." Also in the foot notes, the specific activity for natural uranium is 6.77E-7 Ci/g.

When the limit in footnote 3 to 10 CFR 20, Appendix B, Table 1 is divided by 40 hours and the specific activity of natural uranium is taken into account, the 40-hr time-weighted average uranium concentration limit is 1×10^{-10} µCi / mL. Assuming all the uranium sampled is soluble, this limit is consistent with the soluble uranium intake limit of 10 mg/week specified in 10 CFR

20.1201.2(e). Therefore, the soluble uranium intake (in mg/week) can be calculated from the airborne uranium concentrations to which the worker was exposed.

All measurements and calculations will be done and recorded using standard operating procedures. Typically, airborne particulate concentrations are recorded on an airborne particulate monitoring form, which includes lapel or air particulate sampling flow rates and time of operation, gross alpha measurements, and associated calculations.

Analysis of air filters using gross alpha and alpha spectroscopy methods will yield known concentrations of uranium, 100 percent of which will be converted to mass using the natural uranium specific activity of 677 μCi/g.

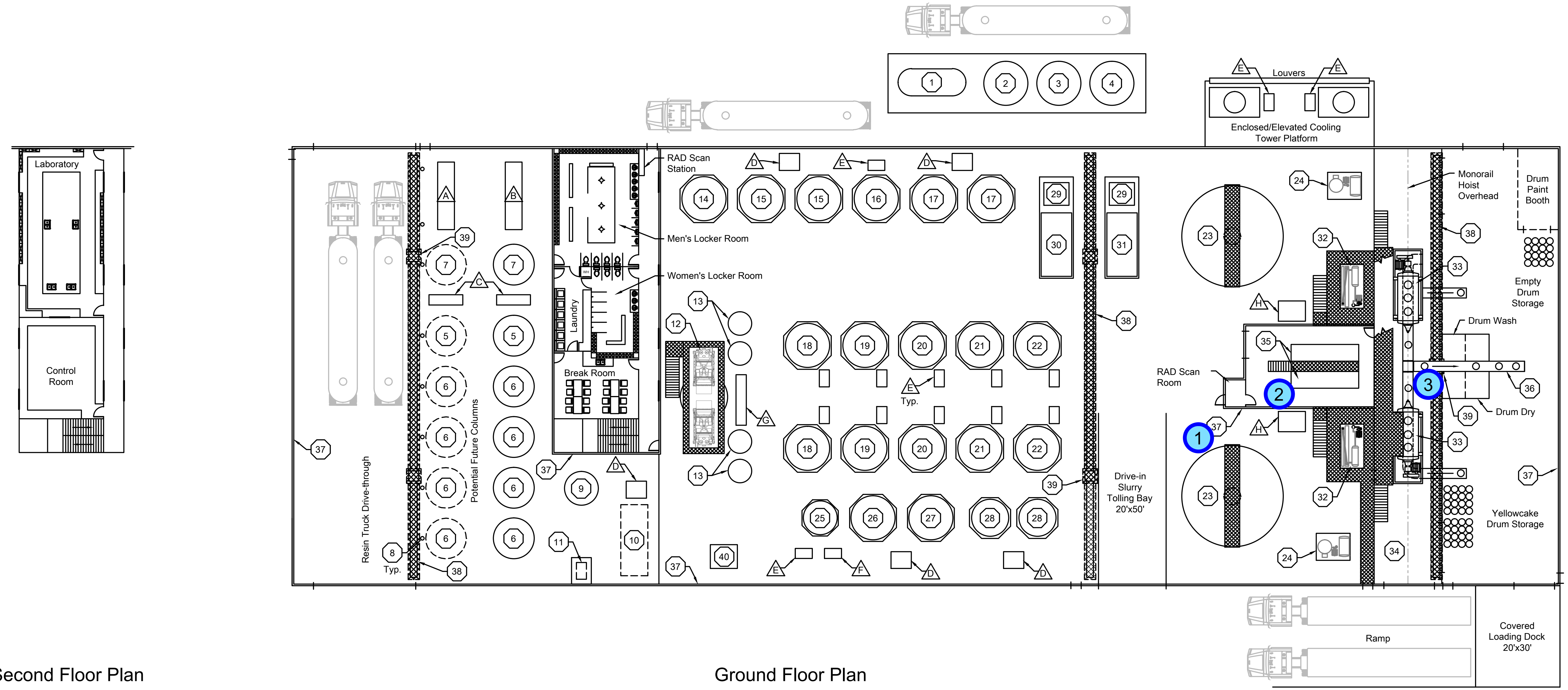
Records will be maintained as described in Section 5.2.5.

The primary ALARA goal for uranium intake will initially be set to less than 25% of the DAC values presented in 10 CFR Part 20, Appendix B, Table 1. In addition, Powertech (USA) will establish a corollary ALARA goal to limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity (see footnote 3 to 10 CFR Part 20, Appendix B, Table 1). After review of the first ALARA audit, modifications determined to be necessary to the facilities, procedures or ALARA program will be developed and implemented in order to further reduce exposures.

Areas meeting one of two criteria will be designated as airborne radioactivity areas. The first criterion is airborne yellowcake concentrations greater than 1×10^{-10} μCi / mL. The second criterion is potential for personnel to be exposed to 25 percent of that concentration, averaged over the number of hours exposed in a week (as recommended in RG 8.30).

Static monitoring stations for airborne radionuclide areas within the CPP are shown on Figure 5.7-9a. For non-airborne radioactivity areas within the CPP, Powertech (USA) will conduct monthly and weekly monitoring for in-plant airborne radionuclides via breathing zone monitoring devices assigned to workers performing specific routine tasks on a random basis. No static monitoring stations for non-airborne radioactivity areas will occur unless required by an RWP. Non-routine task monitoring requirements will be documented in an RWP.

Fixed-location sampler locations will be evaluated annually to confirm that their locations are still appropriate. Included in this evaluation will be the assessment of air flow patterns including potential seasonal variations, changes in worker and equipment locations, and changes in process. Breathing zone samples (lapel samples) for specific tasks are presumed to be representative without further assessment provided the intake of the lapel sampler is within one foot of the worker's head.



Second Floor Plan

Ground Floor Plan

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'∅
6. Process IX Column 12'∅
7. Bleed IX Column 12'∅
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'∅
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'∅
14. Reclamation Make-up Water 13'∅
15. NaCl 13'∅
16. Na_2CO_3 13'∅
17. Utility Water 13'∅
18. Fresh Eluant 13'∅
19. Lean Eluant 13'∅
20. Intermediate Eluant 13'∅
21. Rich Eluant 13'∅
22. Precipitation 13'∅
23. 30'∅ Thickener, 5'∅ Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'∅
26. High TDS Wastewater Tank 13'∅
27. Low TDS Wastewater Tank 13'∅
28. Solids Removal Tank 11'∅
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A: 5'x20' - PC Booster Pumps
- B: 5'x20' - IC Booster Pumps
- C: 3'x10' - Pump
- D: 6'x5' - Pump
- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump

N

Feet: 0, 15, 30, 60
Meters: 0, 5, 10, 20

1. Precipitation Area
2. Filter Press Room
3. Dryer and Packaging Area

Figure 5.7-9a

Proposed Quarterly Air Particulate Sampling Locations

Dewey-Burdock Project

DRAWN BY	Cadd Svcs, Hetrick
DATE	14-Jun-2013
FILENAME	CPP-QtrAirPartSamp.dwg

POWERTECH (USA) INC.

In lieu of weekly 30 minute grab samples specified in RG 8.30, weekly low volume breathing zone samples will be taken from representative workers in airborne radioactivity areas. Breathing zone samples provide a better estimate of airborne particulate concentrations to which workers are exposed, resulting in a more representative estimate of actual intakes. The sensitivity of this method shall be at least 1 x 10^{-11} μCi / mL.

Breathing zone samples will be taken during non-routine operations with potential for a worker to receive exposure to airborne yellowcake above 1 x 10^{-10} μCi / mL. The monitoring type and frequency for non-routine tasks will be described in the job-specific RWP as described in Section 5.2.2

All air samples will be analyzed for uranium within two working days after sample collection. The lower limit of detection (LLD) of all analyses of air samples will be no greater than 1 x 10^{-11} μCi / mL. The calculation of LLDs for measuring concentration of uranium in air is derived from the method to calculate minimum detectable activity (MDA) shown in NRC Regulatory Guide 8.25 "*Air Sampling in the Workplace*".

The technical justification for using the LLD equation in RG 8.25, rather than LLD specified in RG 8.30, is contained in NUREG-1400, Air Sampling in the Workplace (NRC, 1993a), as discussed below.

RG 8.30 uses the following formula to calculate LLD.

$$LLD = \frac{3 + 4.65S_b}{3.7 \times 10^4 EVYe^{-\lambda t}} \qquad \text{(Equation 5.1)}$$

where:

LLD	=	the lower limit of detection (μCi/ml)
S_b	=	the standard deviation of background count rate (counts per second)
3.7×10^4	=	the conversion from disintegrations per second to μCi
E	=	the counting efficiency (counts per disintegration)
V	=	the sample volume (ml)
Y	=	the fractional radiochemical yield if applicable
λ	=	the decay constant for the particular radionuclide
t	=	the elapsed time between sample collection and counting(s)

When performing gross alpha counts on a filter for natural uranium, all counts above background are assumed to be from natural uranium. Thus, the Y variable in the above equation is not

applicable and the exponential term in the denominator goes to 1 due to the long effective half life of natural uranium. Equation 5.1 can then be simplified to the following:

$$LLD = \frac{3 + 4.65S_b}{3.7 \times 10^4 EV} \qquad \text{(Equation 5.2)}$$

S_b is the standard deviation of background count rate (counts per second) and is calculated using Equation 5.3.

$$S_b = \frac{\sqrt{R_b T_s \left(1 + \frac{T_s}{T_b}\right)}}{T_s} \qquad \text{(Equation 5.3)}$$

where:

S_b	=	the standard deviation of background count rate (counts per second)
T_s	=	the gross counting time or sample counting time (s)
T_b	=	the background counting time (s)
R_b	=	the background count rate

The equation proposed in the application to calculate LLD for uranium concentrations in air is shown as Equation 5.4.

$$LLD = \frac{2.71 + 3.29\sqrt{R_b T_s \left(1 + \frac{T_s}{T_b}\right)}}{VEKT_s} \qquad \text{(Equation 5.4)}$$

where:

LLD	=	the lower limit of detection (µCi/ml)
T_s	=	the gross counting time or sample counting time (s)
T_b	=	the background counting time (s)
R_b	=	the background count rate
K	=	the conversion from disintegrations per second to µCi (3.7×10^4)
E	=	the counting efficiency (counts per disintegration)
V	=	the sample volume (ml)

Substituting the variable S_b for the standard deviation of background count rate into Equation 5.4 yields Equation 5.5 below.

$$LLD = \frac{2.71 + 3.29S_b}{KEV} \qquad \text{(Equation 5.5)}$$

A special case of S_b where the background counting time (T_s) equals the sample counting time (T_b) results in the following relationship (Equation 5.6) for S_b:

$$S_b = \frac{\sqrt{R_b T_s}}{T_s}\sqrt{2} = 1.41\ \frac{\sqrt{R_b T_s}}{T_s} \qquad \text{(Equation 5.6)}$$

Substituting Equation 5.6 into Equation 5.5 results in Equation 5.7

$$LLD = \frac{2.71 + 4.65\sqrt{R_b T_s}}{VEKT_s} \qquad \text{(Equation 5.7)}$$

A more rigorous formulation for extreme low-level counting using the exact Poisson distribution was given in Currie, 1972. Here, 2.71 (the Poisson-Normal approximation) is replaced by the exact Poisson value of 3.

Using this value, Equation 5.7 becomes:

$$LLD = \frac{3 + 4.65\sqrt{R_b T_s}}{VEKT_s} \qquad \text{(Equation 5.8)}$$

Powertech (USA) will use Equation 5.8 in the simplified case where the background counting time is equal to the sample counting time if the exact Poisson distribution is used. The effect of using 2.71 versus 3 on the LLD is small and both are appropriate in estimating the LLD for air concentrations. Equation 5.8 is similar to Equation 5.2 (the simplified Regulatory Guide 8.30 equation) in form; however, Equation 5.8 accurately addresses S_b.

5.7.3.3 Respiratory Protection

The respiratory protection program at the facility will be conducted in accordance with NRC Regulatory Guide 8.15 "*Acceptable Programs for Respiratory Protection*" and NRC Regulatory Guide 8.31 "*Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable*", Section 2.7 and 10 CFR 20 subpart H.

PPE in the form of respiratory protective equipment will be mandatory for workers in areas where the use of process and engineering controls may not be adequate to maintain regulated exposure levels to airborne radioactive and/or toxic materials. This protection program will be carried out in accordance with RG 8.15 and RG 8.31 and will be administered by the RSO. The work areas that may have the potential for overexposure are limited to the drying and packaging areas under normal operating conditions.

Criteria for determining when respirators will be required for special job situations or a credible emergency are summarized here. The use of respiratory protection devices will be contemplated only after other measures to limit intake have been considered (10 CFR § 20.1701). If the ALARA evaluation determines process and/or engineering controls are not practicable, Powertech (USA) will increase monitoring and limit intake by controlling access and exposure time; if it is determined the use of respirators will optimize the sum of internal dose and other potential risk, use of a respirator will be implemented in order to keep TEDE ALARA in conformance with RG 8.15. The level of detail addressed during a TEDE ALARA evaluation will be dictated by the potential radiological and physical risk that may be associated with the special job or emergency.

5.7.3.4 Air Monitoring during First Year of Operations

Powertech (USA) will conduct an airborne radiation monitoring program at the project facility that is consistent with the recommendations contained in RG 8.30. The monitoring program will consist of monitoring radon decay products as well as airborne particulate monitoring. During the first year of operation an extensive air particulate program will be implemented in order to evaluate and determine area concentrations of key particulates to which workers may be exposed. Since no conventional ore processing is conducted at an ISR facility, the program will be designed to measure areas where workers may theoretically be exposed to radiological and non-radiological particulates during the daily work routines specific to ISR operations. Breathing zone and particulate monitoring programs are proposed in areas of the CPP where yellowcake is

present (Figure 5.7-9a). Upon analyzing the results from the air particulate measurements, determinations will be made as to the assurance that process and engineering controls are maintaining the concentrations to which workers may be exposed ALARA. Other precautions will be considered based on the data from the primary monitoring program, such as access control to some areas, restrictions on working time within specific areas, and the use of PPE for respiratory protection.

5.7.3.5 Action Levels for Air Sampling Locations

A facility action level of 25% of the DAC for particulate radionuclides and 0.08 WL for radon-222 decay products will be established. If an airborne radionuclide sample exceeds the action level for radioparticulates or radon-222, the RSO will investigate the cause and increase the sampling frequency as appropriate until airborne radionuclide concentration levels do not exceed the action level. An administrative action level will be set at 130 DAC-hours for exposure to radioparticulates and/or radon decay products for any calendar quarter. If the action level is exceeded, the RSO will initiate an investigation into the cause of the occurrence, determine any corrective actions that will reduce future exposures, and document the corrective actions taken. Results of the investigation will be reported to management and the SERP and will be available for NRC inspection. The results of the bioassay program also will be used to evaluate the adequacy of the respiratory protection program at the facility. An abnormally high urinalysis will be investigated to determine the cause of the high result and if the exposure records adequately reflect that such an exposure may have actually occurred.

5.7.3.6 Monitoring for Areas Not Designated as Airborne Radioactivity Areas

Consistent with RG 8.30, Powertech (USA) will implement an air sampling program for areas in the process facility not designated as airborne radioactivity areas. The air sampling program will include quarterly radon decay product grab samples and monthly uranium grab samples. With respect to airborne particulate monitoring, a demonstration that the volume of air sampled is accurately known will be performed via one monthly sample for 30 minutes, or 5-minute weekly grab samples via a high-volume air sampler running at 30 cfm. Powertech (USA) reserves the right to incorporate one or both of these methods into air sampling procedures depending on which method may be most appropriate for a given space not designated as an airborne radioactivity area.

5.7.4 Exposure Calculations

In accordance with 10 CFR 20.1202, the total effective dose equivalent for all radiation workers will be determined by summing the DDE from external radiation and the committed effective dose equivalent (CEDE) from internal radiation.

5.7.4.1 Internal Exposure

CEDEs due to inhalation of yellowcake will be determined by either using the stochastic annual limits of intake (ALIs) listed in Table 1 of 10 CFR 20 or using the derived air concentrations (DACs) listed in the same table. These two methods are described as follows.

Method 1: Use of Stochastic Inhalation ALIs from 10 CFR Part 20

The CEDE for each radionuclide may be calculated using the estimated radionuclide intake, by Equation 2 of RG 8.30 as follows:

$$H_{i,E} = \frac{5I_i}{ALI_{i,E}}$$ Equation 2 from RG 8.30

where:

$H_{i,E}$ = CEDE from radionuclide i (rem)

I_i = Intake of radionuclide i by inhalation during the calendar year (µCi). (If multiple intakes occurred during the year, is the sum of all intakes)

$ALI_{i,E}$ = Value of the stochastic inhalation ALI (based on the CEDE) from Column 2 in 10 CFR Part 20, Appendix B, Table 1 (µCi)

5 = CEDE from intake of 1 ALI (rem). The intake of natural uranium will be determined using the equation listed above in the response to TR RAI 5.7.4-1(a).

If intakes of more than one radionuclide occur, the CEDE will be the sum of the CEDEs for all radionuclides as described below. The intake of natural uranium will be determined using the equation listed below.

Method 2: Use of DACs from 10 CFR Part 20

The CEDE also may be calculated from exposures expressed in terms of DAC-hours. Equation 4 of RG 8.30 demonstrates how the CEDE may be calculated from exposures expressed in terms of DAC-hours.

$$H_{i,E} = \frac{5C_i t}{2000\,DAC_{stoc,i}}$$ Equation 4 from RG 8.30

where:

$H_{i,E}$ = CEDE from radionuclide i (rems)

C_i = The airborne concentration of radionuclide i to which the worker is exposed (µCi/ml)

t	=	The duration of the exposure (hours)
2000	=	The number of hours in a work year
5	=	CEDE from annual intake of 1 ALI or 2000 DAC-hours (rems)

Exposures to airborne natural uranium will be compared to the stochastic ALI or DAC for the "W" class of natural uranium from Table 1 of 10 CFR 20, Appendix B until the actual lung clearance class of the product has been determined.

These methods will be used in non-routine operations, maintenance, and cleanup activities as well as during routine activities where appropriate. For non-routine operations involving an accident scenario, the worker breathing rate assumed in each of the above methods may not be appropriate. If at some point in time alternate methods to evaluate exposure to natural uranium not contained in RG 8.30 or 8.34 are determined to be more appropriate or applicable, these methods will be submitted to the NRC for review and approval prior to use.

The calculation of the committed effective dose equivalents, using either method, will be performed according with RG 8.30, Section C. These calculations will also be supported by the facility's bioassay program described in Section 5.7.5.

The potential intake due to inhalation of natural uranium by personnel in work areas where airborne radioactive materials could exist will be determined using the following formula:

$$I_u = BR \sum_{i=1}^{n} X_i \times t_i \times \frac{1}{PF}$$

where:

I_u	=	Intake of natural uranium for the monitoring period (µg or µCi)
X_i	=	The average air concentration of natural uranium in breathing zone during exposure period (i) (µg or µCi per milliliter)
BR	=	Breathing rate of the worker ($2.0 \text{x} 10^{-4}$ milliliters per minute)
t_i	=	Time of exposure period (i)(minutes)
PF	=	The protection factor based on type of respiratory protection
N	=	Number of exposure periods during monitoring period

Based on industry experience, it is expected that there will only be natural uranium in air, not a mixture of radionuclides. Air samples will be analyzed using gross alpha measurements and, potentially, supported via alpha spectroscopy. Knowing the concentrations of long-lived alpha

emitting radionuclides for various processes, no unknown mixtures of radionuclides in air are expected.

If encountered, exposure calculations will account for mixtures in air using the unity rule as follows:

$$\frac{C_{Th-230}}{DAC_{Th-230}} + \frac{C_{U-nat}}{DAC_{U-nat}} + \frac{C_{Ra-226}}{DAC_{Ra-226}} > 1$$

where:
C = airborne concentration, µCi/ml
DAC = derived air concentration, µCi/ml

The DAC for the mixture will be exceeded if the sum of fractions exceeds unity. If a condition occurs where the radionuclide and mixture of radionuclides are unknown, the DAC for Th-230(W) will be assumed since this is the most restrictive.

It is estimated that airborne uranium concentrations will be well below 25 percent of the derived air concentrations in 10 CFR Part 20 when the plant is at maximum production capacity. This estimate is supported by Section 2.8.4 of NUREG/CR-6733, which states:

"The vacuum dryer has an efficiency in excess of 99 percent for removal of uranium particulates prior to release to the atmosphere. The particles that result from the control system are returned to the drying chamber, thus recovering any uranium particulates. This particulate control system captures virtually all escaping particles."

5.7.4.2 Radon Decay Product Exposure

The amount of radon decay products exposure an employee received in a year will be calculated using the following equation:

$$E_{rd} = \frac{1}{170}\sum_{i=1}^{n}\frac{C_i \times t_i}{PF_i} \qquad \text{Equation 5.9}$$

where E_{rd} is the exposure to radon decay products in working level months (WLM) the employee received in a year, C_i is the average concentration, or working level (WL), of radon decay products of each exposure, t_i is the time of each exposure in hours, PF_i is the respiratory protection factor of each exposure, and n is the number of exposures the employee had during the year.

According to 10 CFR 20 Appendix B, 4 WLM equates to 5 rem CEDE.

Consistent with NUREG-1569, Acceptance Criterion 5.7.4.3(6), the parameters used to evaluate inhalation exposure to radon-222 decay products and to natural uranium will be representative of site conditions as they relate to the maximum production capacity. The calculations will incorporate occupancy time and average airborne concentrations; consequently, both full- and part-time employees (if any) will be considered in these exposure calculations.

5.7.4.3 Prenatal and Fetal Exposure

RG 8.13, Instruction Concerning Prenatal Radiation Exposure (NRC, 1999) provides information to pregnant women and other personnel to help them make decisions regarding radiation exposure during pregnancy, and also provides the definition of a "declared pregnant woman" as stated in Section A of the document. Consistent with RG 8.13, Powertech (USA), in Section 5.5.1, commits to providing this information to workers as appropriate. The information below describes some of the specific information that will be included within Powertech (USA)'s prenatal radiation exposure program consistent with RG 8.13.

- In order for a pregnant worker to take advantage of the lower exposure limit and dose monitoring provisions specified in 10 CFR Part 20, the woman must declare her pregnancy in writing to the licensee.
- The woman's immediate supervisor should receive the written declaration of pregnancy.
- Once a woman has declared a pregnancy in writing, the applicant has the obligation to take steps, including potentially changing the woman's job function, in order to keep doses to the embryo/fetus below regulatory limits contained in 10 CFR § 20.1208 and to levels that are ALARA.
- The RSO is to be consulted if the declared pregnant worker needs additional information.
- The dose to the embryo and fetus is calculated as the sum of the deep-dose equivalent of the declared pregnant worker and the dose to the embryo/fetus from radionuclides in the embryo/fetus and the declared pregnant worker. The calculations will be done according the NRC Regulatory Guide 8.36 *"Radiation Dose to the Embryo/Fetus"*.

5.7.4.4 Reporting and Recordkeeping of Worker Doses

Records showing the results of surveys and calibrations will be maintained for a minimum of three years after the record is made.

Records of all dose assessments, including surveys, measurements, bioassays and calculations used in the dose assessments, will be maintained through license termination in accordance with

recommendations in RG 8.7 and in formats necessary to demonstrate compliance with 10 CFR § 20.2102, 20.2103, 20.2106, and 20.2110.

5.7.5 Bioassay Program

A urinalysis bioassay program will be established at the facility in order to detect employee intakes of uranium. The program will be consistent with the recommendations contained in NRC Regulatory Guide 8.22 "*Bioassays at Uranium Mills*" (RG 8.22). The justification for relying on urinalysis as a primary bioassay technique is provided as follows. Two bioassay techniques are considered in RG 8.22: urinalysis and in-vivo lung measurements. RG 8.22 discusses two triggers for in-vivo lung measurements: 1) when air monitoring or exposure calculations call for in vivo measurement, and 2) when urinalysis results call for in vivo measurements.

The first trigger is when air sampling results indicate an exposure exceeding that resulting from exposure to the more insoluble component of yellowcake at an average airborne concentration of 10^{-10} μCi/ml in a period of 1 calendar quarter. Powertech (USA) will consider the dried yellowcake produced at the Dewey-Burdock Project as Class W natural uranium for radiation protection purposes until determined otherwise. The DAC for Class W natural uranium is 3 x 10^{-10} μCi/ml. The action level for airborne radionuclide concentrations measured minimally on a weekly basis is 25% of the DAC, or in the case of Class W natural uranium an airborne concentration of 7.5 x 10^{-11} μCi/ml. Since controls will be implemented to mitigate airborne concentrations at the established action level, airborne natural uranium concentrations exceeding the air monitoring trigger for in-vivo measurement are unlikely.

Since quarterly average airborne natural uranium (Class W) concentrations are unlikely to exceed the in-vivo lung measurement trigger, urinalysis will be used as the primary bioassay technique. However, in-vivo lung measurement will be considered on a case-by-case basis if urinalysis results indicate that it would be appropriate.

All employees that will handle yellowcake will give a urine sample prior to starting employment and upon termination of employment. During operation of the facility, each employee that has the potential to ingest or inhale yellowcake will give a urine sample on a monthly basis. At a minimum, mechanics/general maintenance workers (7 employees), dryer operators (2 employees), and CPP operators (8 employees) will be sampled on a monthly basis (17 total employees).

Additionally, urine samples will be collected from workers who were exposed to airborne yellowcake suspected of exceeding the 40-hr weekly limit of 1×10^{-10} μCi / mL.

All urine samples will be analyzed for uranium content by a contract laboratory that can achieve a minimum sensitivity of 5 μg/L.

Dose Calculations

The dose from the intake will be estimated by multiplying the estimated intake by the appropriate dose conversion contained in Federal Guidance Report No. 11 (EPA, 1988).

Intakes of uranium will be estimated using the methods described in RG 8.9 (NRC, 1993b). The methods used below apply to the inhalation pathway since it is by the far the most important pathway for potential worker exposure. The following equation will be used to estimate intakes for urine samples collected over a 24-hour period:

$$I = \frac{A(t)}{IRF(t)} \qquad \text{Equation 5.10 (RG 8.9)}$$

where:
I = Estimate of intake with units the same as A(t)
A(t) = Numerical value of the bioassay measurement obtained at time t (μCi)
IRF(t) = Intake retention fraction corresponding to type of measurement for time t after estimated time of intake

The IRF(t) for Class D and Class W, given a 30-day urine bioassay monitoring interval, is 4.7E-3 and 1.3 E-3, respectively (ICRP, 1988).

If the total urine sample is not collected over a 24-hour period, the following formulas will be used to estimate the intake:

$$\Delta A_i = C_i E_i \, (t_i - t_{i-1}) \qquad \text{Equation 5.11}$$

$$A_t = \Delta A_1 + \Delta A_2 + \ldots \Delta A_i \qquad \text{Equation 5.12}$$

where:
ΔA_i = Amount of uranium in sample (μCi)
i = The sequence number of the sample
C_i = The uranium concentration in urine of sample i (μCi/L)
E = Daily urine excretion rate (1.4 and 1.0 L/d for standard man and standard woman, respectively)
t_i = time (d) after intake that sample i is collected
A_i = Total amount (mg) excreted up to time t

Using the calculated A_i, the worker intake will be estimated using Equation 5.10 and the IRF(t) given above.

Corrective Actions

The following corrective actions, which are consistent with Table 1 in RG 8.22, will be taken if positive bioassay results are confirmed. If a monthly urinalysis is less than 15 µg/L uranium, no action will be taken. If the monthly urinalysis is 15 to 35 µg/L uranium, the cause of the elevated uranium will be identified and corrected. A determination will be made as to the potential for other workers' exposure and bioassays conducted as necessary. Work assignment limitations and/or respiratory protection will be considered. Uranium effluent controls will be also be reviewed for possible improvements. If the amount of uranium detected in a monthly urinalysis is greater than 35 µg/L, and has been confirmed in two consecutive specimens, then the actions mentioned above will be taken. Additionally, the urine specimen will be tested for albuminuria, and an in vivo count may be obtained. Work restrictions will be considered for affected employees until urinary concentrations are below 15 µg/L uranium and laboratory tests for albuminuria are negative. Further uranium effluent controls or respiratory protection requirements will also be considered. NRC will be notified as required.

Reporting and Recordkeeping

Consistent with Acceptance Criterion 5.7.6.3(5) of NUREG-1569, Powertech (USA) will conduct record keeping and reporting for the bioassay program in accordance with 10 CFR Part 20, Subparts L and M. Records of all dose assessments will be maintained through license termination. All bioassay results, including negative (i.e., < action level of 15 µg/l) results, will be retained in employee personnel files. For results confirmed in excess of action levels, an internal dose assessment will be performed including information obtained from follow-up actions and investigations including follow-up bioassay results, if applicable. Powertech (USA) will submit a written report to NRC within 30 days after confirmation of results in excess of action levels. The report will contain estimates of each individual's dose, the levels of radiation and concentrations of radioactive material involved, the cause of the elevated exposures, dose rates or concentrations, and corrective steps taken or planned to ensure against a recurrence. Sections 5.2.5 and 5.2.6 contain additional information regarding reporting and recordkeeping.

5.7.6 Contamination Control Program

Powertech (USA) will conduct a contamination control program at the project facilities consistent with recommendations contained in RG 8.30. The purpose of the program is to prevent contamination from spreading to unrestricted areas and needlessly exposing people to radiation. The contamination control program will address potential contamination spreading from restricted areas (process areas as well as general plant areas), from personnel working in those areas, and from equipment and PPE used in those areas. Areas will be classified as restricted based on the potential for risks to workers from exposure to radiation and radioactive materials (10 CFR Part 20). This potential for risks from radiation exposure encompasses airborne radiation as well as radioactive materials on surfaces. The program will also address the survey equipment used to locate contamination. The ALARA goal for contamination control is to reduce the residual contamination on personnel and equipment to be released from the controlled area to as low as reasonably achievable.

5.7.6.1 Areas

Restricted areas include those with surface contamination above 5,000 dpm alpha per 100 cm^2 (averaged over no more than 1 m^2), spots of contamination above 15,000 dpm alpha per 100 cm^2 (averaged over no more than 100 cm^2), or removable contamination above 1,000 dpm alpha per 100 cm^2.

To meet the ALARA concept, surfaces in restricted areas exposed to the air will be limited to having surface contamination of 220,000 dpm alpha per 100 cm^2.

Unrestricted areas will be spot checked weekly for removable surface contamination. If a spot check finds an area of removable surface contamination above background in an unrestricted area, that area will be cleaned and resurveyed for removable surface contamination.

The limits established for alpha and beta-gamma radiation shall apply independently where surface contamination by both alpha and beta-gamma radiation exists. Beta contamination surveys will be performed in those areas of operations that involve direct handling of large quantities of aged yellowcake. Unrestricted area surveys (areas where food is allowed, change rooms, and offices) will be conducted weekly. The total beta-gamma contamination limit for these surveys will be 1,000 dpm/100 cm^2. After facilities have been built, each area will be monitored and a background level established. After background has been established, the action levels for each area will be determined. The beta-gamma surveys for contamination within controlled areas (e.g., well fields) will be conducted monthly; the limit for these surveys will be 1,000 dpm/100 cm^2.

5.7.6.2 Personnel

Personnel working in restricted areas as described in Section 5.7.6.1 will wear protective clothing to mitigate the potential for skin contamination.

Personnel exiting restricted areas with potential removable surface contamination will be monitored for skin and clothing contamination in order to prevent the spread of contamination to unrestricted areas and to keep doses ALARA. Areas of skin measured to be above background will be washed until they no longer read above background. Clothing measured to have alpha contamination above background will be laundered or properly disposed. Soles of shoes reading higher than background alpha levels will be washed and scrubbed until they are no longer above that value. Each survey of personnel leaving a restricted area and the subsequent decontamination will be documented.

Since any beta–gamma contamination at a uranium ISR facility must be associated with alpha emitting nuclides, no special monitoring or survey for beta–gamma emitters will be used for contamination monitoring for personnel. The lack of detectable alpha contamination assures no beta–gamma contamination.

The individual(s) with skin contamination will conduct self-decontamination if physically able to do so. If necessary, the RSO, the RST or a qualified and trained radiation worker will conduct the skin decontamination and verify that background levels have been achieved. The RSO will verify that correct procedures were followed and follow up with an investigation, if appropriate.

Additionally, random surveys of personnel by a member of the radiation protection staff will be conducted quarterly to ensure that the contamination control program is performing adequately.

5.7.6.3 Equipment

Equipment leaving restricted areas with removable contamination will undergo decontamination followed by a survey for removable contamination in order to prevent the spread of contamination to unrestricted areas. Radiation surveys for alpha radiation and beta-gamma radiation in restricted areas will be conducted by the RSO, the RST, or a qualified and trained radiation worker under the supervision of the RSO. Equipment found to have average radiation levels at or below 5,000 dpm alpha (or beta-gamma) per 100 cm^2 (averaged over no more than 1 m^2), removable contamination at or below 1,000 dpm alpha (or beta-gamma) per 100 cm^2, and spots (areas 100 cm^2 or smaller) at or below 15,000 dpm alpha (or beta-gamma) per 100 cm^2 will be cleared for unrestricted use. Equipment that exceeds the contamination limits will undergo

further decontamination until the contamination is below the limits or until decontamination yields no reduction in contamination. Equipment with contamination above any of the limits after attempts of decontamination will be properly disposed. Each survey of equipment leaving a restricted area and the subsequent decontamination will be documented.

Consistent with NUREG-1569, Acceptance Criterion 5.7.6.3(7), the radioactivity of the interior surfaces of pipes, drain lines, or duct work used to convey radionuclides will be determined by making radioactivity measurements at all accessible traps, drains and other appropriate access points that would likely be representative of the radioactivity on the interior of the pipes, drain lines or duct work. If a representative surface cannot be accessed, the pipe, drain line, duct work used to convey radioactive material or similar item will be considered contaminated and not released for unrestricted use from the site.

Consistent with NUREG-1569, Acceptance Criterion 5.7.6.3(6), Powertech (USA) will make a reasonable effort to minimize any radioactive contamination before the use of any covering. Radioactivity on equipment or other surfaces will not be covered with paint, plating, or other covering material unless contamination levels, as determined by a radioactivity survey and properly documented, are below the limits specified in Enclosure 2 to Policy and Guidance Directive FC-83-23, as updated (NRC, May 28, 2010, pg. 41, Section 6.3, Item #2).

5.7.6.4 Respirators

Respirator hoods and face pieces will be surveyed for removable surface contamination before each reuse. Any pieces that have removable surface contamination above background will be decontaminated or replaced. Each survey of respirator hoods and face pieces and the subsequent replacement will be documented.

5.7.6.5 Survey Instrumentation

For tests of removable alpha contamination, swipes or wipes will be used and then counted with an alpha detector designed for sample counting. The same method will be used for testing for removable beta-gamma radiation except the counting will be done with a beta-gamma detector designed for sample counting.

For other measurements for surface contamination, a battery-operated portable alpha detector will be used to directly measure the surface for alpha contamination and a battery-operated portable beta-gamma detector will be used to directly measure the surface for beta-gamma contamination.

In each scenario, the alpha detector used will be able to detect alpha radiation ranging from 100 to 220,000 dpm per 100 cm^2 and the beta-gamma detector used will be able to detect beta-gamma radiation ranging from 1,000 to 15,000 dpm per 100 cm^2.

The instrumentation will be calibrated according to the manufacturer's specifications annually or at the manufacturer's recommended interval, whichever is more frequent.

5.7.6.6 Reporting and Recordkeeping

Consistent with NUREG-1569, Acceptance Criterion 5.7.6.3(5), Powertech (USA) will record and maintain contamination control program information and data as required by 10 CFR Part 20, Subpart L. The records will be retained for 3 years after the records are made. Powertech (USA) will immediately report any event involving source and byproduct materials possessed by Powertech (USA) that may have caused or threatens to cause any of the conditions listed in 10 CFR § 20.2202. Powertech (USA) will submit a written report to NRC within 30 days after confirmation of any of the reportable events listed in 10 CFR § 20.2203. The report will describe the extent of exposure of individuals to radiation and radioactive material and other information as described in 10 CFR § 20.2203. Sections 5.2.5 and 5.2.6 contain additional information on reporting and recordkeeping.

5.7.7 Airborne Effluent and Environmental Monitoring Program

Powertech (USA) will conduct an airborne effluent and environmental monitoring program during operations consistent with recommendations in NRC Regulatory Guide 4.14 "*Radiological Effluent and Environmental Monitoring at Uranium Mills*" (RG 4.14). The program will consist of sampling air, water, vegetation, livestock, and surface soil. Powertech

(USA) will develop, implement and maintain monitoring and quality assurance/quality control programs that ensure consistency for purposes of comparison of data results within and between phases of pre-operation, operations and restoration and reclamation activities where applicable.

Operating philosophies in Regulatory Guide 8.10 will be implemented to determine that concentrations of radon and decay products will be maintained ALARA. Administratively, action levels of 25% of the DAC for airborne radionuclides will be established. Exceedances of the action levels will trigger an investigation to evaluate the performance of existing controls and potentially implement new controls to mitigate airborne radionuclide concentrations.

Additionally, Section 4.1.1 states that results of monitoring obtained during initial plant operations will be used to adjust monitoring programs and upgrade ventilation and/or other effluent control equipment as necessary.

Monitoring results will also be evaluated in routine audits conducted by the RSO and third parties. Included in these audits will be an evaluation of spatial and temporal trends for these monitoring results. These audits provide another opportunity to evaluate whether concentrations of radon and decay products are ALARA.

Throughout the application Powertech demonstrates through commitments for implementing management controls, engineering controls, radiation safety training, radon monitoring and sampling, and auditing programs that there are multiple methods by which concentrations of radon and radon decay products will be determined to be ALARA.

5.7.7.1 Air Monitoring

Operational air monitoring locations (air particulate and radon-222 track-tech detectors) are shown in Figure 5.7-10. This figure includes an updated annual wind rose. The five proposed operational monitoring locations are the same as the corresponding pre-operational monitoring locations, allowing the comparison of operational data with pre-operational data. Section 2.9.6 provides information regarding placement of pre-operational air particulate sampling stations as they apply to Regulatory Guide 4.14. Since the placement of pre-operational air monitoring stations is consistent with recommendations contained in Regulatory Guide 4.14, the placement of operational air monitoring stations is also consistent with Regulatory Guide 4.14.

The filters from air samplers operating continuously will be analyzed quarterly for natural uranium, thorium-230, radium-226, and lead-210. Samplers will have sensors to measure total

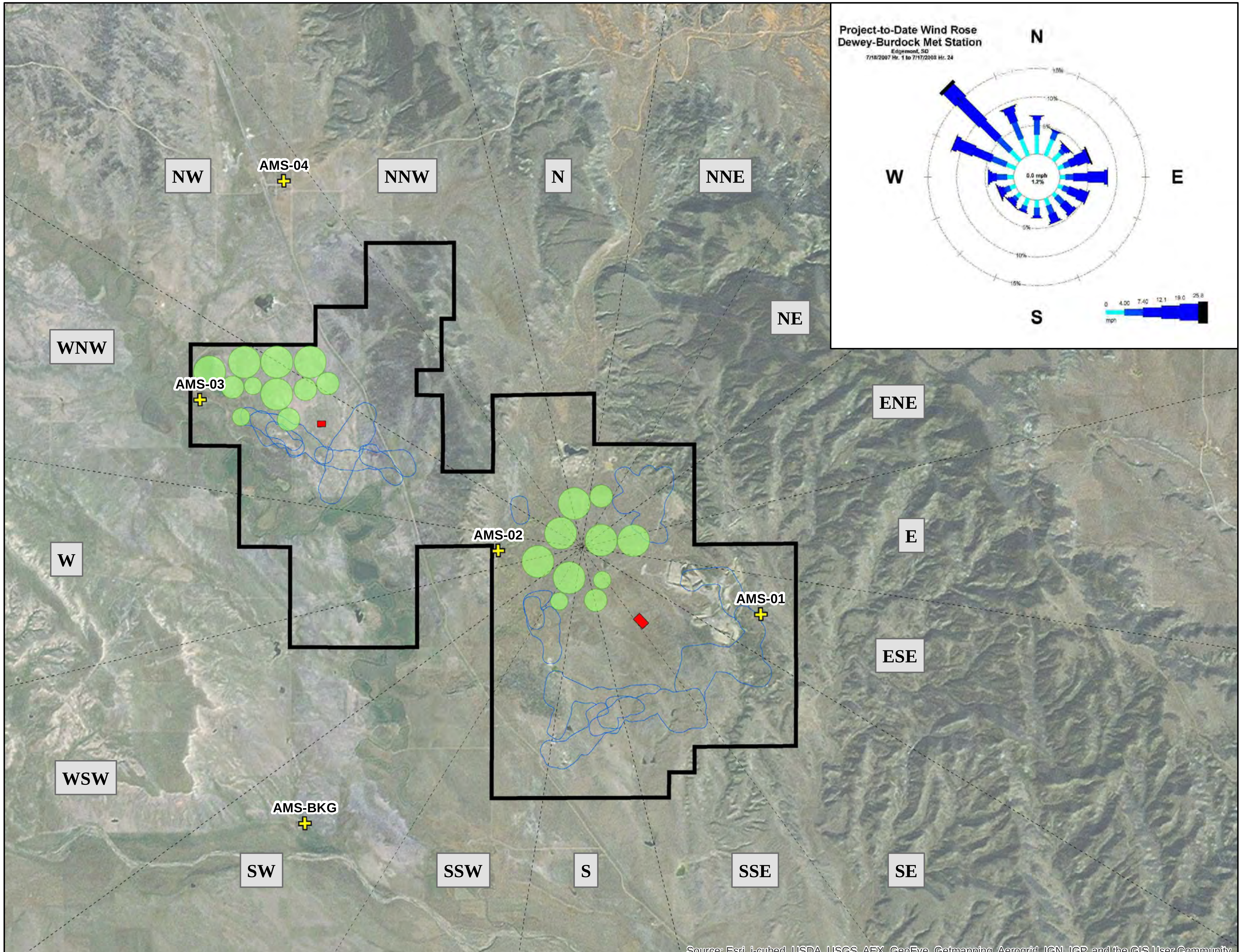
air flow within a sampling period. The maximum LLDs for the analyses will be consistent with the recommendations of RG 4.14.

Powertech (USA) will change filters from the operational air samplers bi-weekly or more frequently if required for dust loading. The operational air particulate samplers will be brushless, automatic flow control hi-vol air samplers similar to those used during pre-operational monitoring. Each air sampler will be equipped with a variable speed motor, controlled by a programmable logic controller (PLC). The PLC will receive input from a mass air flow sensor placed in the air flow path downstream of the filter paper. Any changes in the pre-set flow rate due to dust loading, barometric pressure or temperature will be detected by the air flow sensor. The PLC will compensate for the change by adjusting the motor speed to maintain the pre-set flow rate.

Air samplers will also be equipped with air flow totalizers, which will be recorded and reset during each filter change. Based on the use of modern, automatic flow control air samplers, the recommendation in Regulatory Guide 4.14 to change filters weekly is obsolete. When Regulatory Guide 4.14 was issued, automatic flow control air samplers were unavailable, resulting in the need for weekly filter changes. As described in Section 2.9.6, use of automatic flow control air samplers along with visual observations and flows recorded during each filter change confirmed that the bi-weekly filter changes was sufficiently frequent to avoid reduction in performance due to dust loading during pre-operational monitoring. Similarly, Powertech (USA) will monitor air sampler performance during operational monitoring and change filters bi-weekly or more frequently if required for dust loading.

There will be no stacks at the Dewey-Burdock Project. There will be release points (e.g., vents) that will be sampled quarterly. The grab samples will be isokinetic in nature and will be analyzed for natural uranium, thorium-230, radium-226, and lead-210. The maximum LLDs for the analyses will be consistent with recommendations of RG 4.14.

Powertech (USA) will sample for radon-222 using passive track-etch detectors located at each air monitoring station on a monthly basis, which is consistent with Regulatory Guide 4.14 and NUREG-1569, Acceptance Criterion 5.7.7.3(1).



Legend

- Land Application Area
- Air Monitoring Station
- Potential Well Field Area
- Project Boundary
- Processing Plants

High volume air particulate, TLDs and radon track etch detectors located at each air monitoring station

Feet: 0, 2,500, 5,000, 10,000
Meters: 0, 1,000, 2,000, 3,000
N

Figure 5.7-10

Operational Air Monitoring Locations

Dewey-Burdock Project

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DATE	17-Jun-2013
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5.7.7.1.1 Estimating Airborne Release of Radon

The airborne release of radon (the principal radionuclide potentially released) from process operations will be estimated using the methods described in Section 7.3 and in Regulatory Guide 3.59, Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (NRC, 1987). Important parameters used to estimate the airborne releases will be monitored as part of routine process performance parameters. These parameters include but are not limited to the following:

- Average production lixiviant flow rate
- Average restoration flow rate
- Average bleed rate
- Radium-226 concentration of pregnant lixiviant
- Uranium concentration of pregnant lixiviant
- Number of operating days
- Land application rate
- Radionuclide concentration of land application solutions
- Radionuclide soil concentrations of land application areas
- Identification of potential point and diffuse source locations.

Although potential airborne uranium emissions to unrestricted areas are not expected, performance of the vacuum dryer and emission control systems for the dryer will be monitored as part of typical process performance parameters.

The results of airborne radionuclide release surveys, including location and strength (i.e., quantity of each radionuclide in Ci/yr) of point and diffuse airborne emissions, based on important parameter monitoring will be reported in the semiannual effluent reports required by 10 CFR § 40.65.

5.7.7.1.2 Estimating Public and Occupational Exposure to Radon Decay Products

The primary method to account for public exposure to radon decay products is to evaluate the dose from radon and its decay products at receptor locations in and around the project area using environmental monitoring data and Equation 5.13 below.

$$\boldsymbol{CEDE = DCF \times C_{net} \sum_i OF_i \times EF_i} \qquad \text{(Equation 5.13)}$$

where:

CEDE = Annual committed effective dose equivalent from radon-222 (mrem/yr).

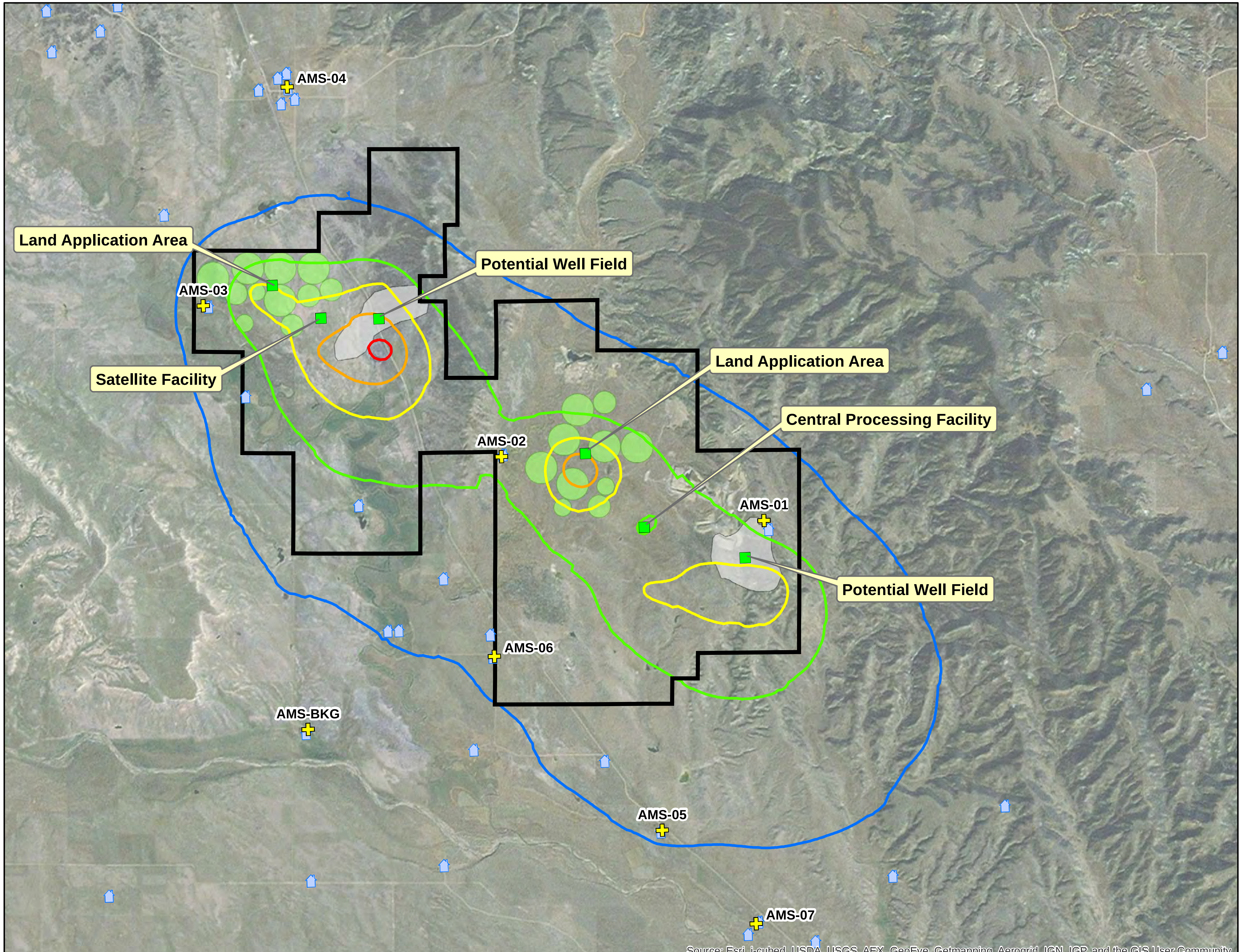
C_{net}	=	Net annual average radon-222 concentration (annual average concentration at location minus annual average concentration at background location) (pCi/L).
OF_i	=	Occupancy factor for location or conditions; in above equation will usually be 1 unless different equilibrium factors for indoor and outdoor radon-222 exposures are used.
EF_i	=	Radon-222 decay products equilibrium fraction; will assume indoor and outdoor fraction of 0.5. May adjust outdoor fraction based on MILDOS-AREA modeling.
DCF	=	Dose Conversion Factor of 500 mrem/pCi L^{-1} at 100% equilibrium (from 10 CFR 20, Appendix B, Table 2).

The member of the public likely to receive the highest dose from licensed operations is a resident at air monitoring station AMS-02. Locations of operational air monitoring stations are shown on Figure 5.7-10. Passive track-etch detectors will be deployed at each operational monitoring station for monitoring radon-222 on a quarterly basis.

The above method is a conservative approximation of dose from radon-222. Given the difficulty in measuring low-level radon-222 concentrations resulting from site activities within the varying background radon-222 concentrations in and around the project area, an alternate approach to the above method may be used as needed. The alternate approach would be to model the dose to the receptor of concern using MILDOS-AREA. Inputs into MILDOS-AREA will be the location and strength of source terms based on estimated airborne releases reported as required by 10 CFR § 40.65, the site-specific meteorological data updated as needed for the current year, and receptor location. An example of this approach using pre-operational meteorological data is provided below.

Consistent with the requirements of 10 CFR §20.1501, Figure 5.7-11 presents the results of modeling the annual total effective dose equivalent (TEDE) above background in and around the project area. The analysis was performed using MILDOS-AREA as a predictive model to estimate doses at regularly spaced (1 X 1-km grid spacing) arbitrary receptors within and around the project area using the same input parameters and source terms described in Section 7.3. Isodose contour lines were developed using kriging interpolation methods based on the results of the MILDOS-AREA modeling of the arbitrary receptors.

The isodose lines shown on Figure 5.7-11 are adult doses based on continuous occupancy. The highest predicted dose is around 6 mrem/year southeast of the Dewey portion of the project area. Assuming a worker is in the project area for 2,000 hours per year, the expected annual occupational dose from gaseous and particulate releases would be less than 2 mrem/year. If a



Legend

- Source
- Air Monitoring Station
- Resident
- Project Boundary
- Potential Well Field
- Land Application Area

MILDOS Isodose Contours (mrem/yr)

- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

Feet: 0, 2,500, 5,000, 10,000

Meters: 0, 1,000, 2,000, 3,000

N

Figure 5.7-11

MILDOS Isodose Lines

Dewey-Burdock Project

DRAWN BY C. Farr - ERG

DATE 17-Jun-2013

FILENAME MILDOSIsodoseLines.mxd

POWERTECH (USA) INC.

worker not associated with the Dewey-Burdock Project (i.e., a member of the public) were to work the entire year within the project area, no public dose limits will be exceeded.

Assuming a member of the public uses the project area for recreation or other purposes for 2 weeks per year, the expected annual public dose from gaseous and particulate releases would be less than 1 mrem/year. It is likely that any member of the public working or otherwise using the land within the project area would be there for a small fraction of time compared to a resident potentially living within the project area. Consequently, the member of the public likely to receive the highest dose from the licensed operation would be a resident living near the facility continuously during the year. The residence closest to and downwind from the facility is AMS-02 as described previously. The predicted TEDE at this location ranges from 2.21 mrem/year for an adult to 4.5 mrem/per year for an infant. The AMS-02 location is included in the proposed environmental monitoring program for radon-222, air particulate, and exposure rate monitoring.

This analysis is based on the use of best professional practices to ensure effluent limits are ALARA, including use of pressurized, downflow IX columns, modern vacuum dryer, building ventilation, and extensive control, alarm, and monitoring systems. This will ensure that ISR operations are conducted so that all airborne effluent releases, occupational doses, and doses to members of the public are reduced to levels that are ALARA in accordance with 10 CFR Part 40, Appendix A, Criterion 8, 10 CFR 20.1101(b) and NUREG-1569, Acceptance Criterion 4.1.3(5).

The analysis is also in agreement with NUREG-1910 (NRC, 2009), which states, “Doses for the various ISL facilities…are at least a factor of three below the regulatory limit and most are less than that. Based on operational history and dose-modeling results, doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and overall potential radiological impacts from ISL operations would be SMALL” (pg. 4.3-33). NUREG-1910 also provides information regarding typical employee exposure to radon decay products. For one ISR facility monitored over a 13-year period, maximum employee exposure to radon decay products ranged from 0.213 to 0.643 working-level months, or from 2.5 to 16 percent of the occupational exposure limit of 4 working-level months. NUREG-1910 concludes, “Because these average and maximum exposure levels range from 2.5 to 16 percent of the occupational exposure limit of 4 working-level months, doses from normal radon releases would be expected to have a SMALL impact on the workers” (pg. 4.2-55). Figure 5.7-11 supports the expectation that the areas with the highest potential for occupational doses occur within the confined structures of the facility where gaseous and particulate emissions potentially could concentrate.

5.7.7.2 Biota Monitoring

Following is a description of the operational monitoring programs for vegetation, crops, livestock and fish, and game animals. Powertech (USA) commits to attaining the LLDs in RG 4.14 or, at a minimum, alternate LLDs, if agreed to by the NRC in the operational monitoring phase of the project. Powertech (USA) commits to utilizing well trained field personnel and to working closely with contract laboratory personnel in order to ensure LLDs are consistent with NRC guidance in RG 4.14.

<u>Vegetation</u>

Samples of vegetation will be collected three times during the grazing season at each air monitoring station presented on Figure 5.7-10. These air monitoring locations are located in three different sectors having the highest predicted airborne radionuclide concentrations due to milling operations, which is a siting criterion for the air monitoring stations. Justification regarding the placement of these air monitoring stations as they apply to recommendations in RG 4.14 is provided in Section 2.9.6. The samples of vegetation will be analyzed for radium-226 and lead-210.

Based on MILDOS-AREA results that show the total effective dose equivalent (TEDE) from all pathways is less than 5% of the applicable radiation protection standard (the modeled dose to potential maximally exposed member of the public is approximately 3 mrem/year), Powertech (USA) does not believe that the ingestion pathways from grazing animals is a potentially significant pathway exceeding 5% of the applicable radiation protection standard. However, Powertech (USA) will sample vegetation during the first year of operations for comparison to baseline data. If analysis and MILDOS-AREA determine that there is not a significant pathway, Powertech (USA) will propose to modify the monitoring plan to not include the sampling of vegetation or forage as part of the operational monitoring program. This is consistent with the recommendations contained in RG 4.14.

<u>Crops</u>

Based on MILDOS-AREA results that show the TEDE from all pathways is less than 5% of the applicable radiation protection standard (the modeled dose to potential maximally exposed member of the public is approximately 3 mrem/year), the ingestion pathway from crops would not likely exceed 5% of the applicable radiation protection standard. If the pre-operational garden vegetable soil sample results described in Section 2.9.10 supported by MILDOS-AREA modeling demonstrate no significant exposure pathway, Powertech (USA) will not sample crops, including vegetable gardens, as part of the operational monitoring program. This approach is consistent with the recommendations contained in RG 4.14.

Livestock and Fish

Powertech (USA) commits to collecting livestock samples annually, consistent with guidance contained in RG 4.14. RG 4.14 focuses animal food sampling on grazing animals and fish. Poultry are not grazing animals. Fish will be collected semiannually provided they exist in water bodies that may be subject to seepage or surface drainage from potentially contaminated areas. Livestock and fish samples will be collected and analyzed for uranium (natural), thorium-230, radium-226, lead-210 and polonium-210.

Powertech (USA) commits to livestock sampling and analysis during the first year of operations for comparison to baseline. These annual grab samples taken at the time of harvest or slaughter will be analyzed for natural uranium, radium-226, thorium-230, lead-210 and polonium-210. Livestock samples will include cattle, pigs and other livestock present at the time of sampling; number and type will depend upon availability. Currently, cattle and pigs are the only livestock within the 3.3 km area. If the presence of other livestock is found during the annual land use survey, Powertech (USA) will seek the livestock owner's approval to collect tissue samples at the time of slaughter.

If the analysis of livestock tissue supported by the annual MILDOS-AREA modeling indicates grazing animals demonstrate no significant exposure pathway, Powertech (USA) will modify the monitoring program appropriately and submit to the NRC for approval. This is in accordance with Regulatory Guide 4.14, Table 2, footnote "o," which states, "Vegetation or forage sampling need be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway (an exposure pathway should be considered important if the predicted dose to an individual would exceed 5% of the applicable radiation protection standard)."

Powertech (USA) does not propose to sample poultry. While chickens also are currently present within 3.3 km of the project area, they are fed grains not originating from the project area and are not considered grazing animals.

Fish species with the potential for human consumption (green sunfish and channel catfish) have been recorded in the area will be sampled semiannually, if present in water bodies potentially affected by contamination.

Game Animals

Powertech (USA) does not propose to sample wild game due to the precedent from recently approved NRC license applications (e.g., Moore Ranch) that have not provided game animal tissue sample analyses due to the migratory nature and relatively large home range of game animals in relation to the size of the project area. These animals would not be a significant pathway to man, which Regulatory Guide 4.14 lists as a criterion for sampling in the operational monitoring program. This will be confirmed through annual MILDOS-AREA modeling.

5.7.7.3 Surface Soil Monitoring

Samples of surface soil (0-5 cm) will be collected annually at each of the air monitoring stations shown in Figure 5.7-10. The samples will be analyzed for natural uranium, radium-226, and lead-210. Powertech (USA) commits to attaining the LLDs in RG 4.14 or, at a minimum, alternate LLDs, if agreed to by the NRC in the operational monitoring phase of the project.

5.7.7.4 Direct Radiation Monitoring

Consistent with recommendations contained in RG 4.14, thermoluminescent dosimeters (TLDs) or equivalent dosimeters will be co-located with the air particulate samplers. Powertech (USA) will utilize environmental, low-level TLDs provided by a National Voluntary Laboratory Accreditation Program (NVLAP) approved provider. The dosimeters will be exchanged quarterly. The results will be used to assess quarterly gamma exposure rates at each of the sites.

5.7.7.5 Sediment Monitoring

During operations, Powertech (USA) will conduct annual sediment sampling at the operational surface water monitoring locations. Sections 2.7.3.1 and 5.7.8.1 describe the impoundments and stream sampling sites included in the operational monitoring program. All samples will be analyzed for natural uranium, Th-230, Ra-226, and Pb-210, which is consistent with Table 2 of Regulatory Guide 4.14.

5.7.8 Ground-Water and Surface-Water Monitoring Programs

5.7.8.1 Surface Water Operational Monitoring Program

During ISR operations, 24 impoundments, identified during the 2007 field survey, and 10 stream sampling sites (depicted on Plate 5.7-1) will be monitored as part of the operational monitoring program. The location of each impoundment in relation to proposed activity was used to determine whether the impoundment will be included in the operational monitoring program.

Table 5.7.8-1 lists all of the impoundments and identifies which impoundments are located down-gradient (i.e., potentially subject to surface runoff) from proposed activity or within potential well field areas. The table also denotes the 24 impoundments included in the operational monitoring program, including 2 Darrow pits not included in the baseline monitoring program. Justification for the impoundments not included is provided in the table and is typically due to the impoundment not being located downstream of all proposed activities. All 24 impoundments identified for operational monitoring will be visited on a quarterly basis throughout construction and operation. In addition, Powertech (USA) will visit all 24 of the impoundments included in the operational monitoring program four times (including pre-operational samples already collected) prior to operations to satisfy the Regulatory Guide 4.14 pre-operational monitoring recommendations. Water samples will be collected, when available, and analyzed for constituents listed in Table 2.7-22, which is consistent with Table 2.7.3-1 of NUREG-1569 and Table 1 of Regulatory Guide 4.14.

The pre-operational stream sampling sites were evaluated against guidance in Regulatory Guide 4.14 to establish an operational monitoring program. Table 5.7.8-2 provides a list of the stream sampling sites proposed for operational monitoring. The table includes 10 stream sampling sites, including 6 new sites, as depicted on Plate 5.7-1. Four sites (BVC01, BVC04, PSC01, and PSC02) used for baseline monitoring will be replaced with operational monitoring sites that better meet the guidance in Regulatory Guide 4.14 as follows:

- BVC11 will be located where Beaver Creek exits the project area. This monitoring location will replace BVC01, which was approximately 2 stream miles further downstream, below the confluence with Pass Creek.
- BVC14 will be located where Beaver Creek enters the project area. This monitoring location will replace BVC04, which was approximately 12 stream miles upstream from the project area.
- PSC11 will be located where Pass Creek exits the project area. This monitoring location will replace PSC01, which was approximately 2 stream miles upstream from the PSC11 location, within the project area.
- PSC12 will be located where Pass Creek enters the project area. This monitoring location will replace PSC02, which was about 2 stream miles upstream from the project area

In addition to the four new sites described above, Powertech (USA) will establish two additional sites on unnamed tributaries in the southeast portion of the project area.

Table 5.7.8-1: Impoundments Included in Operational Monitoring Program

Site	Type/Name	Down-Gradient of Proposed Activity*	Included in Operational Monitoring Program	Justification for Not Including in Operational Monitoring Program
Sub01	Stock Pond	No		Not down-gradient and outside of project area
Sub02	Triangle Mine Pit	No	**Yes**	
Sub03	Mine Dam	Yes	**Yes**	
Sub04	Stock Pond	Yes	**Yes**	
Sub05	Mine Dam	Yes	**Yes**	
Sub06	Darrow Mine Pit Northwest	Yes	**Yes**	
Sub07	Stock Dam	Yes	**Yes**	
Sub08	Stock Pond	Yes	**Yes**	
Sub09	Stock Pond	Yes	**Yes**	
Sub10	Stock Pond	Yes	**Yes**	
Sub11	Stock Pond	Yes	**Yes**	
Sub20	Stock Pond	Yes	**Yes**	
Sub21	Stock Pond	Yes	**Yes**	
Sub22	Stock Pond	Yes	**Yes**	
Sub23	Stock Pond	No		Not an impoundment, infrequent, small pool of water due to inadequate storm water control at county road crossing
Sub24	Stock Pond	No		Outside of project area, not located in a project area drainage
Sub25	Stock Pond	No		Outside of project area, not down-gradient
Sub26	Stock Pond	No		Outside of project area, not down-gradient
Sub27	Stock Pond	Yes		Outside of project area, downstream of Sub28
Sub28	Stock Pond	Yes		Outside of project area, downstream of Sub08 and Sub09 with no proposed activity between Sub08 or Sub09 and Sub28
Sub29	Stock Pond	Yes	**Yes**	
Sub30	Stock Pond	Yes	**Yes**	
Sub31	Stock Pond	Yes	**Yes**	
Sub32	Stock Pond	Yes	**Yes**	
Sub33	Stock Pond	Yes	**Yes**	
Sub34	Stock Pond	Yes	**Yes**	
Sub35	Stock Pond	Yes	**Yes**	
Sub36	Stock Pond	Yes	**Yes**	

Table 5.7.8-1: Impoundments Included in Operational Monitoring Program (cont.)

Site	Type/Name	Down-Gradient of Proposed Activity*	Included in Operational Monitoring Program	Justification for Not Including in the Operational Monitoring Program
Sub37	Stock Pond	Yes		Downstream of Sub36
Sub38	Stock Pond	No		Outside of project area, not down-gradient
Sub39	Stock Pond	No		Not down-gradient
Sub40	Darrow Mine Pit Southeast	Yes	**Yes**	
Sub41	Stock Pond	Yes		Only down-gradient of potential perimeter monitor wells
Sub42	Stock Pond	No		Not down-gradient
Sub43	Stock Pond	No		Not down-gradient
Sub44	Stock Pond	No		
Sub45	Stock Pond	No		Outside of project area, not down-gradient
Sub46	Stock Pond	No		Outside of project area, not down-gradient
Sub47	Stock Pond	No		Outside of project area, not down-gradient
Sub48	Stock Pond	No		Outside of project area, not down-gradient
Sub49	Darrow Mine Pit	Yes	**Yes**	
Sub50	Darrow Mine Pit	Yes	**Yes**	

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

Table 5.7.8-2: Operational Stream Sampling Locations

Site ID	Name	Sample Type	Location in NAD 27, South Dakota State Plane South (feet)	
			Northing	Easting
BVC11	Beaver Creek Downstream	Grab	433,638	1,022,546
BVC14	Beaver Creek Upstream	Grab	446,829	1,012,976
CHR01	Cheyenne River Upstream	Grab	423,009	1,016,699
CHR05	Cheyenne River Downstream	Grab	405,925	1,047,227
PSC11	Pass Creek Downstream	Passive sampler	431,452	1,028,064
PSC12	Pass Creek Upstream	Passive sampler	446,470	1,031,222
BEN01	Bennett Canyon	Passive sampler	416,196	1,047,473
UNT01	Unnamed Tributary	Passive sampler	422,482	1,039,166
UNT02	Unnamed Tributary	Passive sampler	424,478	1,035,236
UNT03	Unnamed Tributary	Passive sampler	425,438	1,029,910

Prior to ISR operations, Powertech (USA) will sample each site monthly (including samples already collected) for 12 consecutive months in accordance with Regulatory Guide 4.14 pre-operational monitoring recommendations. Grab samples will be collected from sites BVC11, BVC14, CHR01, and CHR05. Passive samplers will be installed at the remaining sites to collect samples during ephemeral flow events. Water samples will be analyzed for constituents listed in Table 2.7-22, which is consistent with Table 2.7.3-1 of NUREG-1569 and Table 1 of Regulatory Guide 4.14.

Operational Surface Water Sampling Methods and Parameters

Impoundments will be sampled quarterly by collecting grab samples. Prior to sampling, the sampler will conduct a visual survey of the impoundment to identify an appropriate sample location. This will include an area free of ice or floating debris and with sufficient water depth to permit sample collection without disturbing sediments. If necessary, a clean, long-handled dip sampler will be used. Typically the sample location will be near the impoundment embankment where the water is deepest. Grab samples will be collected in clean sample containers provided by the contract laboratory. Water will be obtained by filling the containers from the top 10 cm (4 in) of the water column. Samples will be field-preserved where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory. In the event that a sample cannot be collected from an impoundment during the quarterly visit, the reason will be stated on a field sheet and reported accordingly.

Streams will be sampled by quarterly grab sampling or with automatic samplers. Perennial stream sampling locations include those on Beaver Creek and the Cheyenne River. These will be sampled by collecting grab samples as described above. Passive samplers (single-stage samplers) will be installed at all other stream sampling sites from April through October. These will automatically collect samples when the flow rate in the channel reaches a field-adjustable minimum depth threshold. Following the runoff event the water will be manually transferred from the temporary sample container to clean sample bottles and submitted to the contract laboratory for analysis.

Representative water of that collected in the grab samples will be analyzed in the field for pH, conductivity and temperature. Impoundment and stream samples will be analyzed for the parameters presented in Table 5.7.8-3, which is consistent with Regulatory Guide 4.14.

Table 5.7.8-3: Operational Surface Water Monitoring Parameter List and Analytical Methods

Parameter	Units	Analytical Method
Uranium, dissolved	mg/L	E200.8
Uranium, suspended	mg/L	E200.8
Ra-226, dissolved	pCi/L	E903.0
Ra-226, suspended	pCi/L	E903.0
Th-230, dissolved	pCi/L	E907.0
Th-230, suspended	pCi/L	E907.0
Pb-210, dissolved	pCi/L	E909.0M
Pb-210, suspended	pCi/L	E909.0M
Po-210, dissolved	pCi/L	RMO-3008
Po-210, suspended	pCi/L	RMO-3008

5.7.8.2 Groundwater Operational Monitoring Program

The operational groundwater monitoring program will include domestic wells, stock wells, irrigation wells and wells located hydrologically upgradient and downgradient of proposed activity. This is an alternate operational groundwater monitoring program to what is recommended in Regulatory Guide 4.14. The operational monitoring program is designed to provide a comprehensive baseline evaluation of water supply wells located within 2 km of the potential well field boundaries. Wells proposed for operational monitoring include domestic and irrigation wells within 2 km of the potential well field boundaries, stock wells within the project area, and additional monitor wells in the alluvium, Fall River, Chilson and Unkpapa.

Prior to operations all domestic, stock, and irrigation wells within 2 km of the boundary of each proposed well field (provided the owner consents to the sampling and the well condition is suitable for sampling) will be sampled to establish baseline water quality. Domestic, stock, and irrigation wells are listed in Appendix 2.2-A and depicted on Plate 2.7-2. To meet the recommendations of Regulatory Guide 4.14, Powertech (USA) will ensure that all domestic, stock and irrigation wells within 2 km of the potential well fields are monitored quarterly for one year prior to operation (including monitoring already completed). All samples will be analyzed for constituents listed in Table 6.1-1, which meets the criteria listed in NUREG-1569 and Regulatory Guide 4.14.

Operational Groundwater Monitoring - Domestic and Irrigation Wells

Prior to operations, all domestic wells within the project area will be removed from private use. Depending on the well construction, location and screen interval, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well. During operations, Powertech (USA) will monitor all domestic and irrigation wells within 2 km of the boundary of each well field (as measured from the perimeter monitoring well ring). Samples will be collected annually and analyzed for the constituents listed in Table 6.1-1.

Operational Groundwater Monitoring - Stock Wells

During the design of each well field, all nearby stock wells will be evaluated for the potential to be adversely affected by ISR operations or to adversely affect ISR operations. At a minimum, all stock wells within ¼ mile of well fields will be removed from private use prior to operation of nearby well fields. Depending on the well construction, location and screen interval, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well. During operation, Powertech (USA) will monitor all stock wells within the project area. Samples will be collected quarterly and analyzed for water level and the three excursion indicators of chloride, total alkalinity, and conductivity.

Operational Groundwater Monitoring - Monitor Wells

As recommended in Regulatory Guide 4.14, Powertech (USA) will monitor wells located hydrologically upgradient and downgradient of proposed activity as part of the operational groundwater monitoring program. A list of the monitor wells included in the operational monitoring program is provided in Table 5.7.8-4. Monitor wells included in the operational monitoring program are depicted on Figures 5.7.8-1 through 5.7.8-6 and include wells completed in the alluvium, Fall River, Chilson, and Unkpapa. The monitor wells will be monitored quarterly and analyzed for constituents listed in Table 6.1-1.

Monitoring conducted as part of the operational monitoring program will be conditional upon land owner access and suitable conditions allowing proper collection of a sample. If access is not available during the time of monitoring, a second attempt will be made to collect a sample during the monitoring period. If a well cannot be accessed continually, Powertech (USA) will propose an alternate monitoring location or remove the well from the operational groundwater monitoring program.

Operational Groundwater Sampling Methods and Parameters

Groundwater sampling methods will be the same as the methods utilized for baseline characterization. Static water level will be measured before sample collection when access is

Table 5.7.8-4: Monitor Wells Included in Operational Monitoring Program

Well ID	Qtr-Qtr	Section	Township	Range	Relative Position
Alluvium					
676	SESW	34	6S	1E	Downgradient of Land App.
677	SWSW	27	6S	1E	Downgradient
678	SWNE	4	7S	1E	Downgradient
679	NESW	9	7S	1E	Upgradient
707	SWNE	34	6S	1E	Downgradient of Triangle Pit
708	SESW	3	7S	1E	Downgradient of Land App.
709	SENW	15	7S	1E	Downgradient of Well Field
TBD	NWNW	20	6S	1E	Upgradient
TBD	NENE	31	6S	1E	Downgradient of Well Field
TBD	NWSE	32	6S	1E	Downgradient of Well Field
TBD	NWNW	20	6S	1E	Downgradient of Land App.
Fall River					
631	SWSW	23	6S	1E	Upgradient
681	NWNE	32	6S	1E	Production Zone
688	NESW	11	7S	1E	Overlying Production Zone
694	NWNW	15	7S	1E	Upgradient
695	SESE	32	6S	1E	Downgradient
698	SENW	2	7S	1E	Downgradient
706	NENE	21	6S	1E	Upgradient
TBD	SWNE	34	6S	1E	Downgradient of Triangle Pit
TBD	NWSE	2	7S	1E	Downgradient of Darrow Pit
Chilson					
43	SWSE	34	6S	1E	Downgradient of Triangle Pit
680	NESW	11	7S	1E	Production Zone
689	NENW	32	6S	1E	Production Zone
696	NWNW	15	7S	1E	Downgradient
697	SESE	32	6S	1E	Downgradient
705	NENE	21	6S	1E	Upgradient
3026	SESE	12	7S	1E	Upgradient
TBD	SWSE	2	7S	1E	Downgradient of Darrow Pit
Unkpapa					
690	NESW	11	7S	1E	
693	NENW	32	6S	1E	
703	SWSE	1	7S	1E	

TBD – To be determined. Well not yet installed.

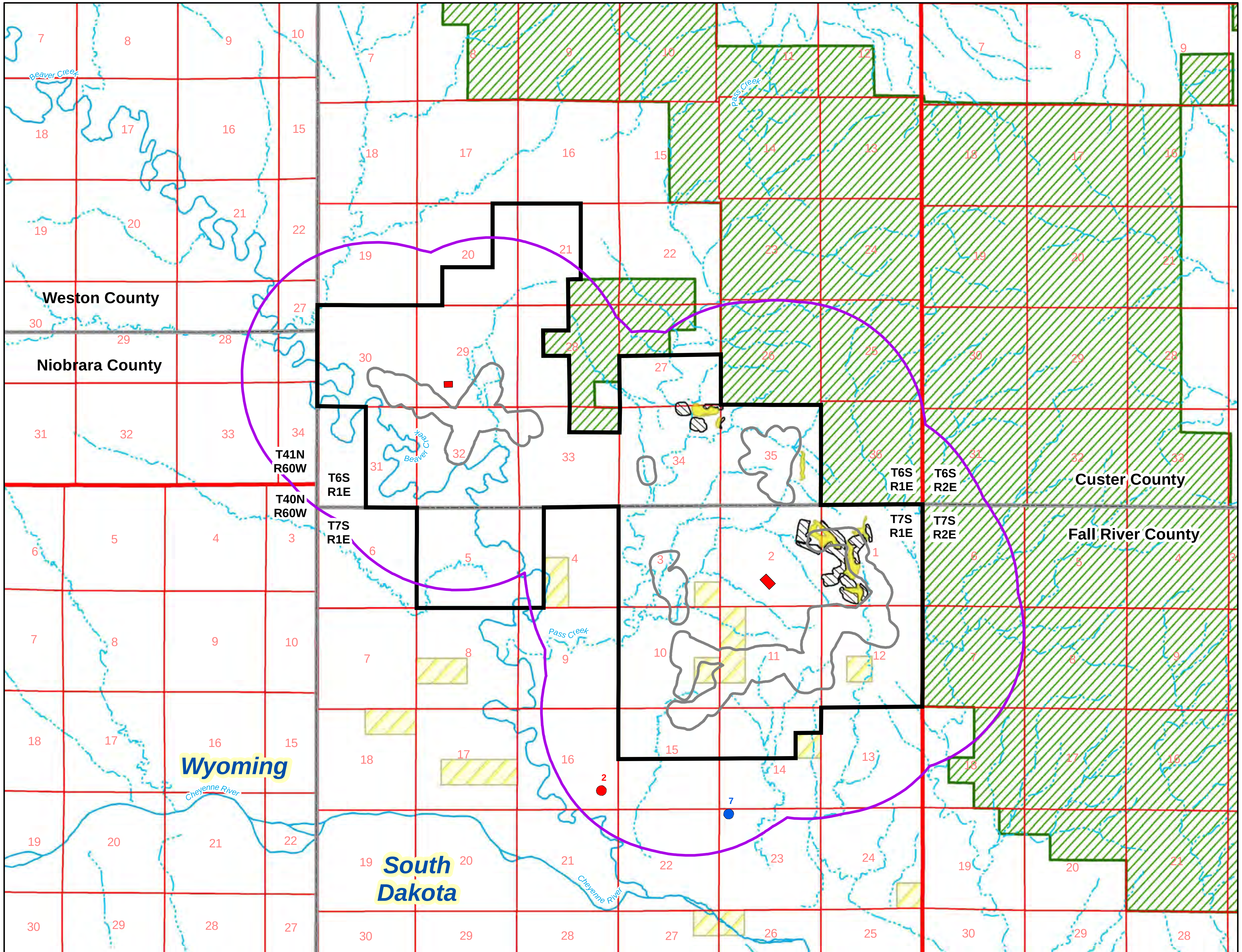


Figure 5.7.8-1

Domestic Wells
Operational Monitoring Locations

Dewey-Burdock Project

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

POWERTECH (USA) INC.

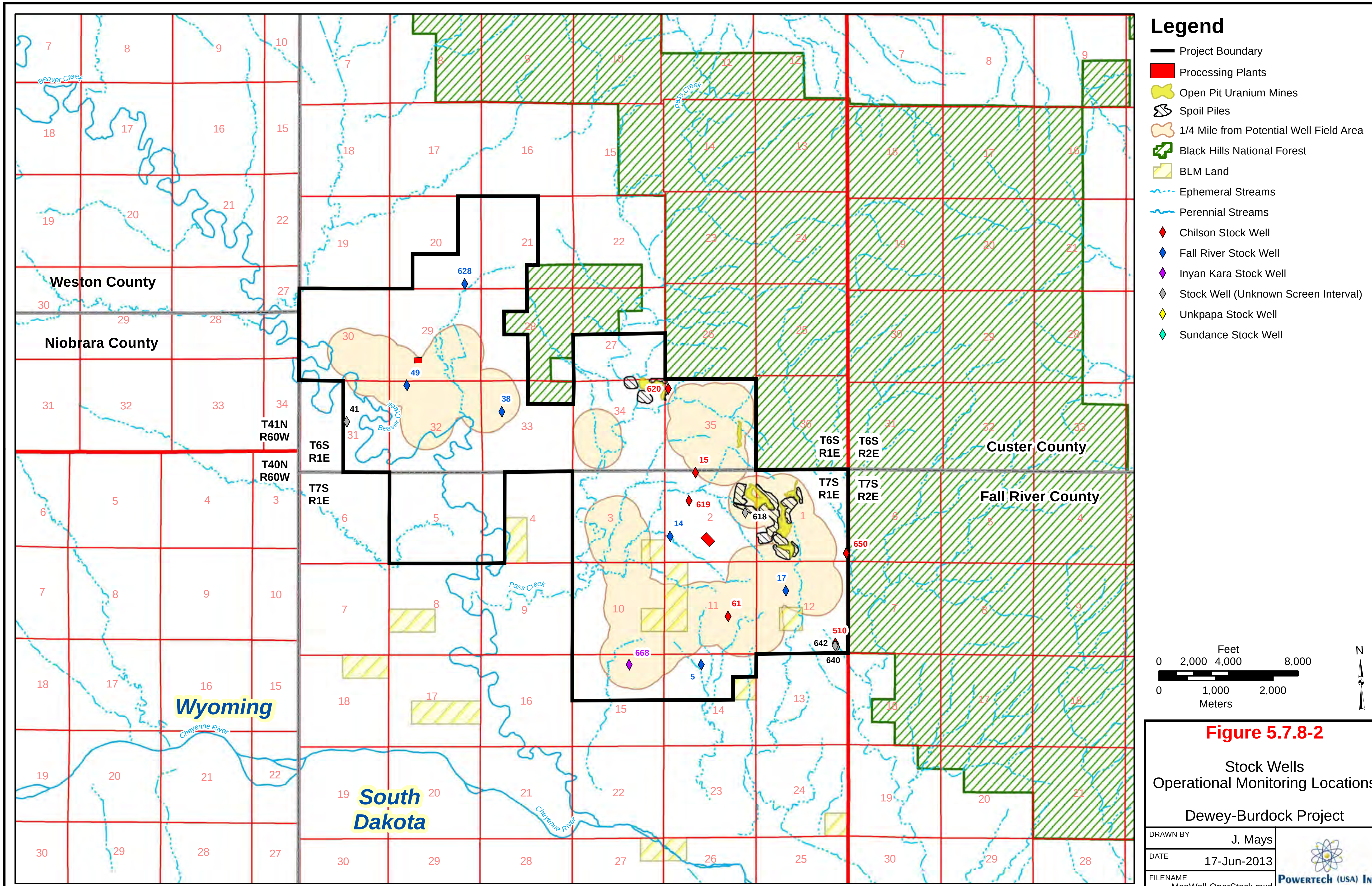


Figure 5.7.8-2

Stock Wells
Operational Monitoring Locations

Dewey-Burdock Project

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

POWERTECH (USA) INC.

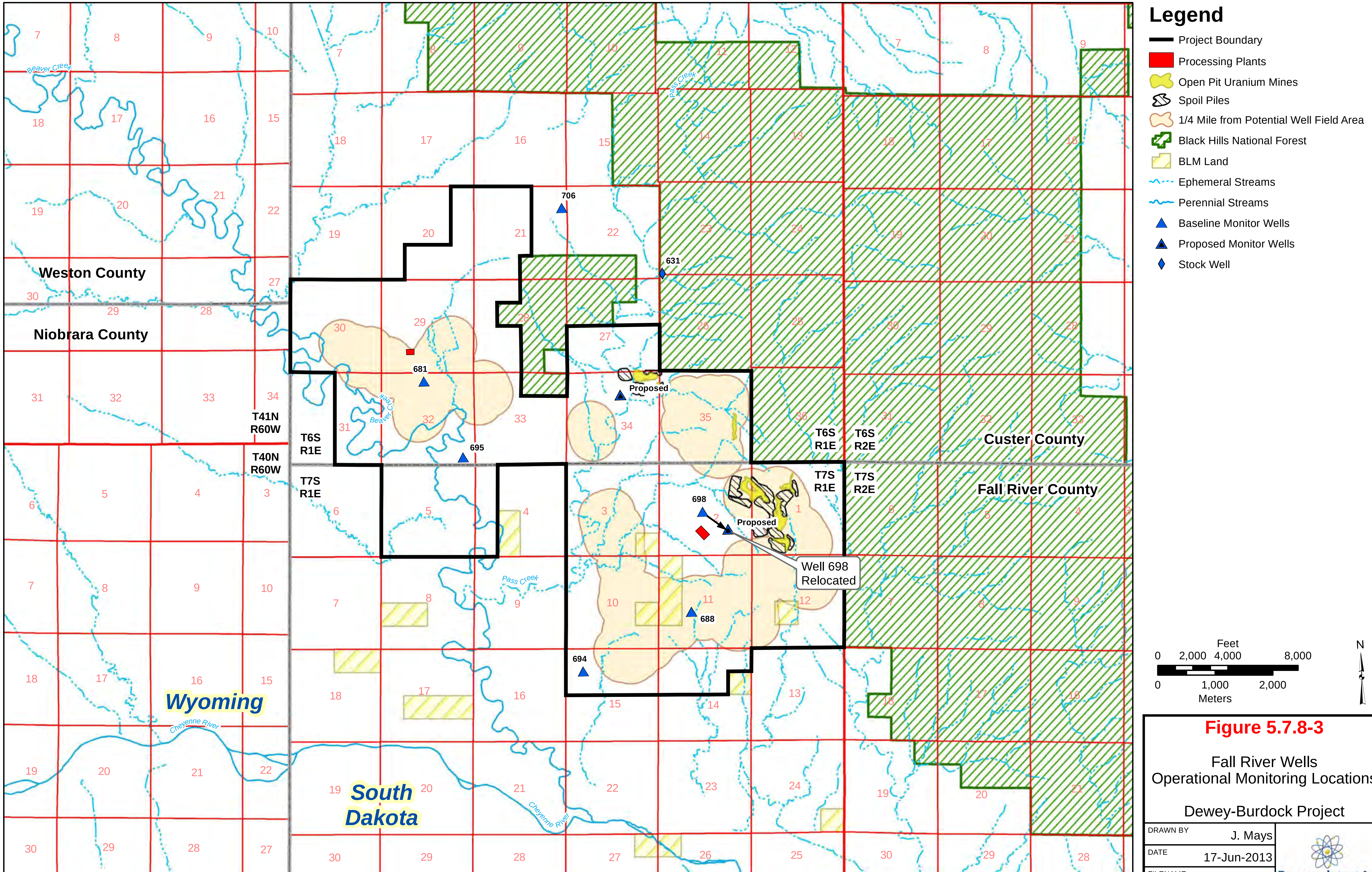


Figure 5.7.8-3

Fall River Wells
Operational Monitoring Locations

Dewey-Burdock Project

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

Powertech (USA) Inc.

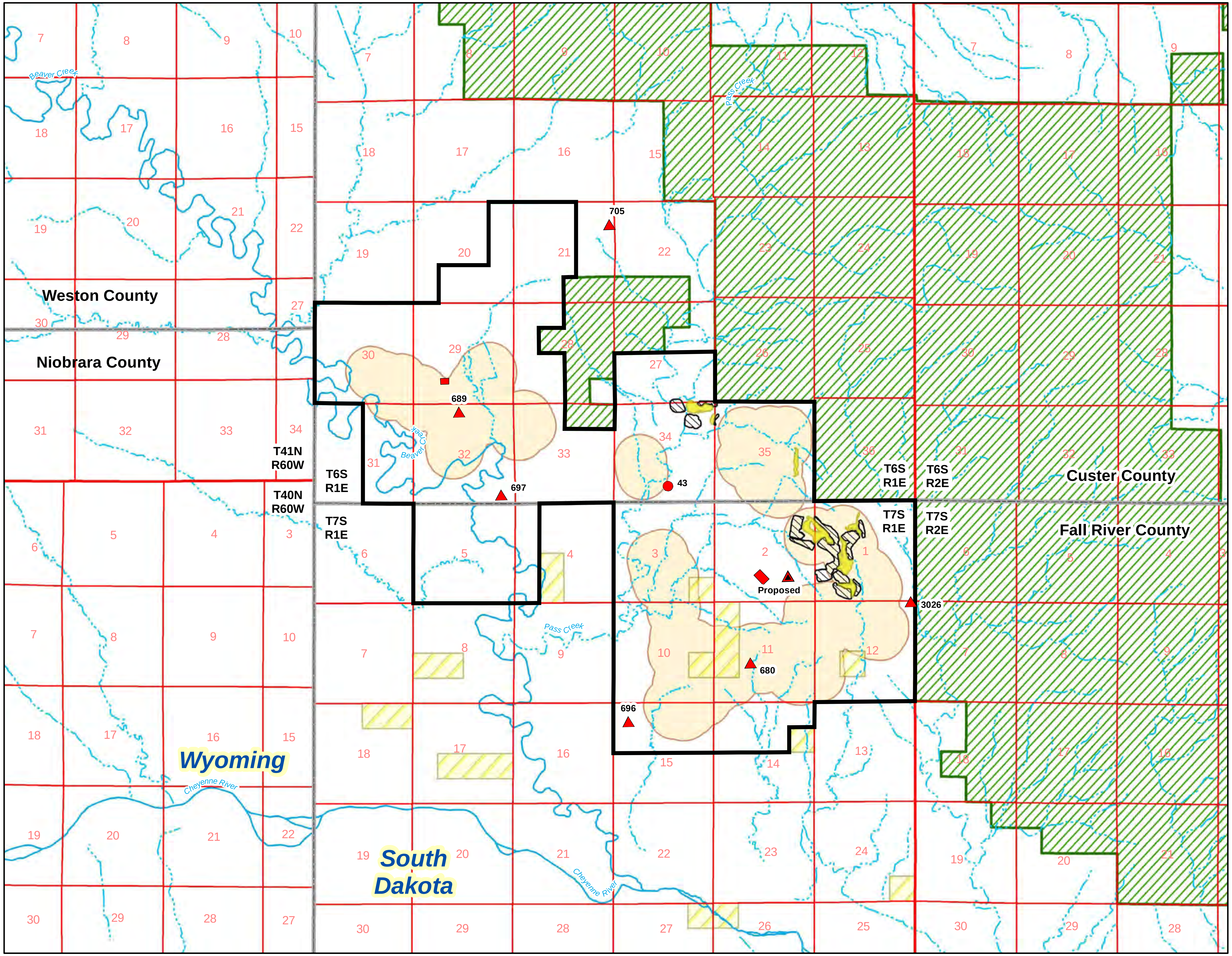


Figure 5.7.8-4

Chilson Wells
Operational Monitoring Locations

Dewey-Burdock Project

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

POWERTECH (USA) INC.

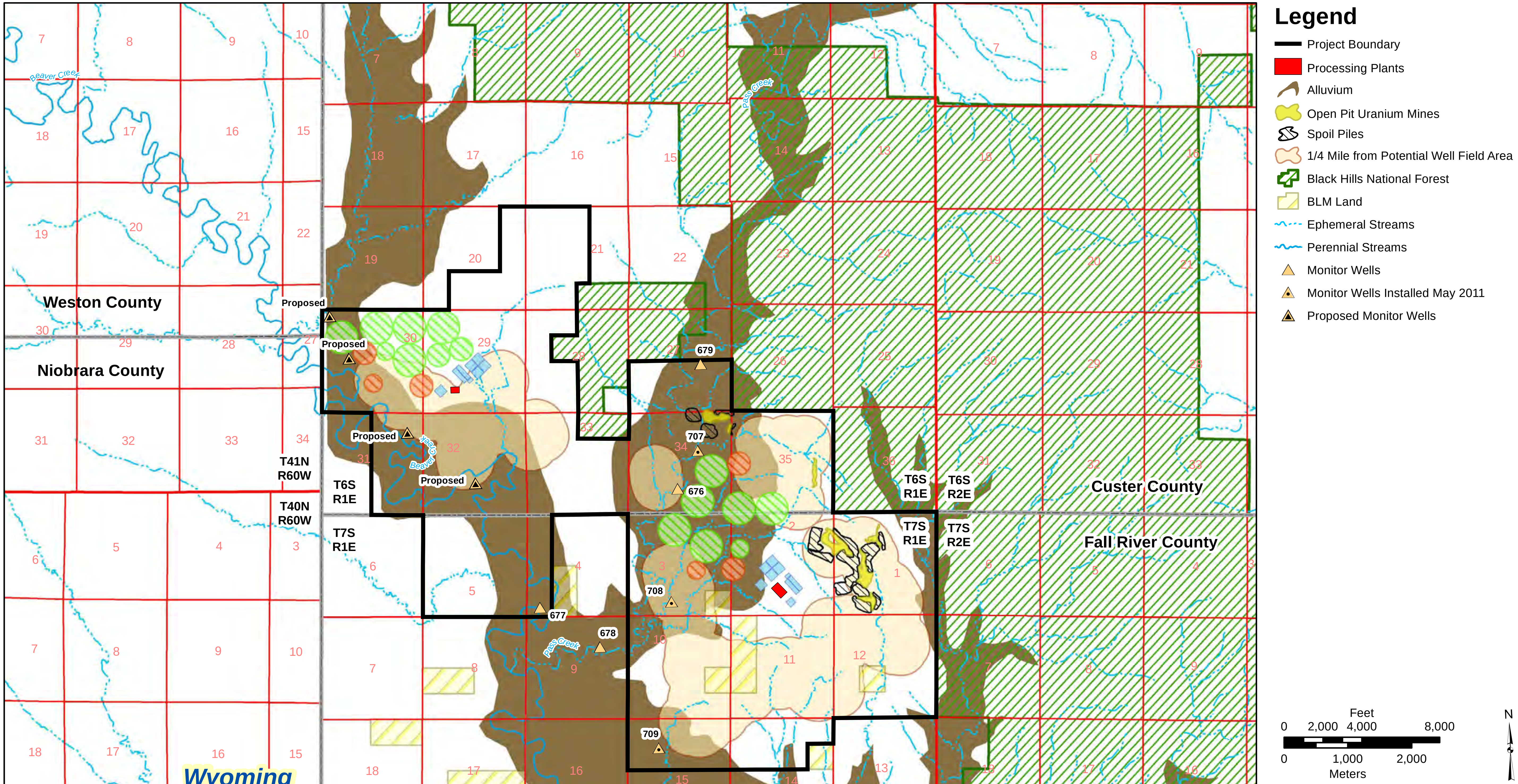


Figure 5.7.8-5

Alluvial Wells Operational Monitoring Locations

Dewey-Burdock Project

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

POWERTECH (USA) INC.

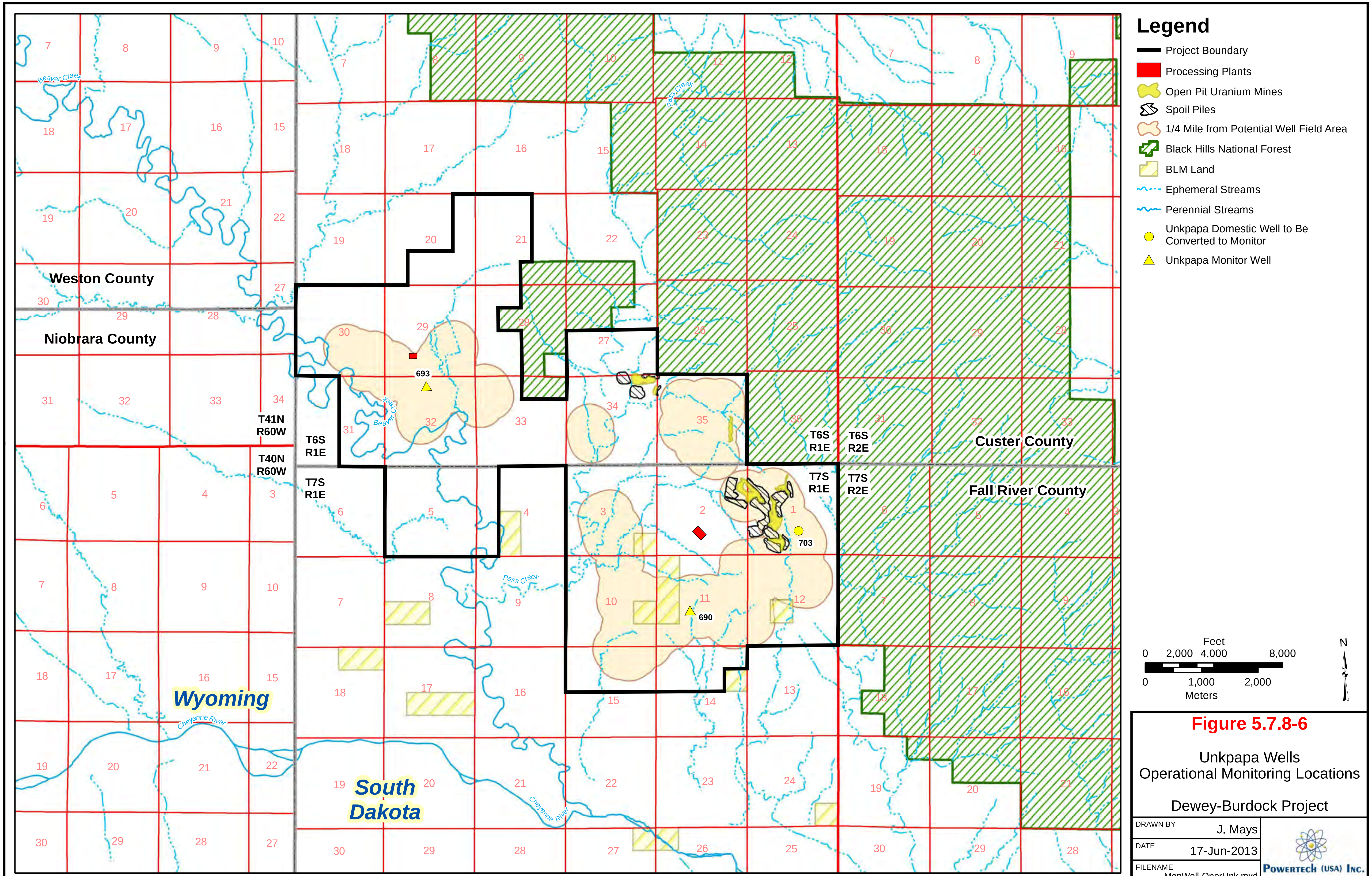


Figure 5.7.8-6

Unkpapa Wells Operational Monitoring Locations

Dewey-Burdock Project

available. Measurement techniques will include pressure transducers, a portable electronic water level meter, or an ultrasonic water level sensor. For flowing artesian wells, the shut-in pressure will be measured, where access is available, using a 15 or 30 psi NIST pressure gauge. Prior to measuring the pressure, the well will be shut in and the pressure allowed to stabilize before recording the hydrostatic pressure.

Three casing volumes will be purged prior to sample collection where possible, except that flowing artesian wells will be assumed to contain representative formation water without purging. In all cases, field parameters will be measured and recorded and samples will not be collected until field pH, conductivity and temperature have stabilized. The criterion used to assess stability will be three consecutive measurements of each of the field parameters with values for each parameter within 10%.

All groundwater samples will be collected in clean sample containers and field preserved, where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory. During operation, all domestic wells within the project area and all stock wells within ¼ mile of well fields will be removed from use. Domestic wells within 2 km of the project area will be sampled annually for the parameters in Table 6.1-1. Stock wells within the project area will be sampled quarterly for chloride, total alkalinity and conductivity. Monitor wells will be sampled quarterly for the parameters in Table 6.1-1.

5.7.8.3 Well Field Production Zone Baseline Groundwater Monitoring

Within each well field a subset of wells that will later serve as production wells will be identified for baseline water quality sampling. These subsets of wells will include at least one (1) well per four (4) acres of well field pattern area, or six (6) wells, whichever is greater. Should the pattern area be 6 acres or less, the maximum density will be one well per acre and a subset of less than six wells may be used. These wells will be sampled four times for baseline characterization, with a minimum of fourteen (14) days between sample events. The samples will be analyzed for all parameters identified in Table 6.1-1.

Prior to calculating baseline water quality statistics, the analytical results will be examined for differences within the production zone. Methods used to determine whether differences exist include visual screening such as the use of trilinear diagrams, and statistical analysis such as the Student's t-test or other accepted methods such as those described in "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance" (EPA, 2009). If heterogeneity exists, then baseline water quality will not be established for the entire production zone but will be separated into subzones. If no statistically significant differences in water quality are present, then baseline water quality will be established for the entire production zone of the well field.

Outliers, which are anomalously high or low values relative to the other values, will not be removed by quality control checks including visual screening and statistical analysis. Typically, an outlier will be defined as a value outside of the mean value, plus or minus three (3) standard deviations, of all values of that parameter within the production zone or subzone, if applicable. The mean value and standard deviation used to identify outliers will be calculated for the entire data set within the production zone or subzone minus the suspected outlier. Other accepted methods may be used to identify outliers including methods described within EPA (2009). Outliers will be examined for potential data transcription or other identifiable errors and corrected if possible. If they cannot be corrected, outliers will be removed from the data set prior to calculating baseline water quality.

For the production zone monitor wells, the baseline water quality will be established as the average on a parameter-by-parameter basis for the entire production zone, for each subzone, or on a well-by-well basis. Alternately, Powertech (USA) may propose the use of a statistical analysis tool such as EPA's ProUCL 4.0, which was described by NRC staff in the January 2011 NRC Uranium Recovery Workshop in Denver, Colorado, to establish baseline water quality based on the distribution of sample results on a parameter-by-parameter basis. The target restoration goals (TRGs) will be established as a function of the average baseline water quality and the variability in each parameter according to statistical methods approved by NRC. The methods used to establish baseline water quality, identify outliers, evaluate variability, and calculate TRGs will be described within the well field hydrogeologic data package for each well field.

5.7.8.4 Excursion Monitoring Program

5.7.8.4.1 Monitor Well Baseline Groundwater Monitoring

All monitor wells will be sampled four times for baseline characterization, with a minimum of fourteen (14) days between sample events. The water level in each monitor well also be recorded during each sampling event. All samples will be analyzed for the parameters listed in Table 6.1-1.

Prior to calculating UCLs, the analytical results will be examined for differences. Methods used to determine whether differences exist include visual screening, such as the use of trilinear diagrams and statistical analysis such as the Student's t-test. If heterogeneity exists, then the UCL for a particular monitor well will be established for that well. If no statistically significant

differences in water quality are present, then the UCLs will be established to represent the entire monitoring zone of the well field.

Outliers, which are anomalously high or low values relative to the other values, will be removed by quality control checks including visual screening and statistical analysis. Specifically, an outlier will be defined as a value outside of the mean value plus or minus 3 standard deviations of all values of that parameter within the same zone. The mean value and standard deviation used to identify outliers will be calculated for the entire data set within the same zone minus the suspected outlier. Data values identified as outliers will not be included in the computation of statistical parameters used for determining the UCLs. Outliers will be examined for potential data transcription or other identifiable errors and corrected if possible. If they cannot be corrected, outliers will be removed from the data set prior to calculating baseline water quality.

5.7.8.4.2 Excursion Indicators and Upper Control Limits

Following characterization of well field baseline water quality, UCLs will be established for constituents that provide early indication of a potential excursion. The constituents proposed for use as UCLs are chloride, conductivity and total alkalinity. Chloride will be used as an excursion indicator because concentrations in the lixiviant are increased by the IX process. In addition, chloride is highly mobile in groundwater and is not influenced by pH changes or oxidation-reduction reactions. Conductivity will be used as an excursion indicator because it provides an overall indication of changes in groundwater quality and is more easily measured than TDS. Total alkalinity will be used as an excursion indicator since concentrations of bicarbonate are increased during ISR operations.

UCLs for each monitor well will be set at the baseline mean concentration of the individual unit or zone being monitored plus five (5) standard deviations for each excursion indicator. Because some aquifers exhibit low chloride concentration with a narrow statistical distribution, for chloride only the greater of the mean plus five standard deviations or the mean plus 15 mg/L will be used as the UCL.

5.7.8.4.3 Excursion Monitor Wells

<u>Monitor Well Configuration</u>

Refer to Section 3.1.3.1 for the monitor well configuration. Monitor wells completed in the perimeter of the production zone and in overlying and underlying hydrogeologic units will be used to monitor for potential excursions.

Perimeter Monitor Well Spacing

The perimeter production zone monitoring ring will be located at a maximum distance of 400 feet from the pattern area. This maximum distance is based on and consistent with standard monitoring practices at operating ISR facilities. As indicated in NUREG-1569, Acceptance Criterion 5.7.8.3(3), "Previously approved *in situ* leach excursion monitoring systems used monitor wells as far as 180 m [600 ft] and as near as 75 m [250 ft] from the well field edge…The licensee should be afforded some discretion in determining the appropriate distance of excursion monitor wells from the well field, but should provide justification for distances greater than about 150 m [500 ft]." The maximum distance also is supported by site-specific data and evaluation through numerical groundwater modeling.

Within the project area, the Fall River and Chilson hydrogeologic units have been extensively characterized, both historically by TVA and more recently by Powertech (USA). Numerous monitor wells have been installed for determination of the potentiometric surfaces. Pumping tests conducted by TVA (Appendix 2.7-K) and by Powertech (USA) (Appendix 2.7-B) have provided site-specific aquifer properties for the Fall River and Chilson. Data derived from the hydrologic testing have been incorporated into numerical models to evaluate well field scale issues related to ISR operations, including monitor ring spacing and excursion control.

Additional numerical modeling will be performed to evaluate well spacing and control of potential excursions for the Chilson well fields. The aquifer properties of the Chilson are similar to those of the Fall River, based on pumping tests conducted by TVA and Powertech (USA). Therefore, results of the modeling for the Chilson well fields are anticipated to be similar to those already completed for the Fall River well fields.

In support of the perimeter monitor ring spacing, numerical modeling has been undertaken to evaluate groundwater conditions related to ISR at the Dewey-Burdock Project (Appendix 6.6-B). The results from the rigorous numerical simulations demonstrate that the maximum spacing of 400 feet is adequate to detect an excursion and that the excursion can be controlled. Petrotek Engineering Corporation's 2010 report, "Numerical Modeling of Groundwater Conditions Related to In-Situ Recovery at the Dewey-Burdock Uranium Project, South Dakota," is included in Appendix 6.6-B.

The model simulations are based on the site-specific hydrogeological conditions and aquifer properties determined for the Dewey well field area from the 2008 pumping test in the Lower

Fall River (Appendix 2.7-B). The result from the 2008 pumping test indicated the average transmissivity to be 255 ft^2/day with an average storativity 4.6 x 10^{-5}. Assuming a 75-foot thickness for the Lower Fall River, the hydraulic conductivity is calculated to be 3.4 ft/day. Total porosity of the Lower Fall River was estimated, based on analysis of core samples, to be 29 percent. These values were the initial values used in the model calibration. Using the site-specific aquifer properties and the observed hydraulic gradient of 0.006 ft/ft, the average groundwater flow velocity was calculated to be 0.07 ft/day, or 26 ft/yr.

Assuming the anticipated production rates to be approximately 20 gpm per well pattern, with a net bleed of approximately 1 percent, the model simulations were conducted to evaluate well field-scale issues related to ISR production. The horizontal well field flare was determined to be 1.19 and the 400-foot well spacing demonstrated through modeling to be adequate to detect a potential excursion at this distance. Model simulations were also used to demonstrate that hydraulic control of the simulated excursion can be established by changing well field operational rates to reverse the hydraulic gradient at a distance of 400 feet and change the direction of groundwater travel back to the well field.

Powertech (USA) anticipates conducting ISR operations concurrently for “stacked” roll front deposits within one hydrogeologic unit. In such cases the perimeter monitor well ring will be located within 400 feet horizontally from the larger production zone, and the monitor wells will be screened across the full thickness of the hydrogeologic unit.

For example, the L2 and L3 ore bodies are within the Lower Chilson sand unit and are separated vertically by approximately 10 feet. Although the L2 and L3 ore horizons will be produced with separated systems of injection and recovery wells, they will be treated as a single production zone for monitoring purposes. There is no evidence that a laterally continuous shale of clay confining unit is present between the L2 and L3 ore bodies that would restrict hydraulic communication between these ore bodies, so they are considered together as one hydrologic unit. The perimeter monitor well ring will be located within 400 feet horizontally from the larger production zone. The monitoring wells in that perimeter monitor ring encompassing the L2 and L3 ore horizons will be screened across the full thickness of the Lower Chilson sand unit, which is estimated to average approximately 65 feet thick.

It is anticipated that ISR operations for these “stacked” roll front deposits will be conducted concurrently. Therefore, monitoring of the entire Lower Chilson sand unit is appropriate to ensure that any potential excursion is detected.

5.7.8.4.4 Excursion Monitoring

All monitor wells will be sampled for excursion indicators at least twice per month and no more than 14 days apart in any given month during ISR operations.

The monitoring program for excursion detection has been designed to comply with NRC guidance of NUREG-1569, Acceptance Criterion 5.7.8.3(5) (NRC, 2003a). An excursion will be deemed to have occurred if two or more excursion indicators in any monitor well exceed their UCLs. A verification sample will be taken within 48 hours after results of the first analyses are received. If the results of the verification sampling are not complete within 30 days of the initial sampling event, then the excursion will be considered confirmed for the purpose of meeting the reporting requirements described below. If the excursion is not confirmed by the verification sample, a third sample will be taken within 48 hours after the second set of sampling data are received. If neither the second nor the third sample confirms the excursion by two indicators exceeding their UCLs, the first sample will be considered to have been in error, and the well will be removed from excursion status. If either the second or third sample exhibits two or more indicators above their UCLs, an excursion will be confirmed, the well will be placed on confirmed excursion status, and corrective action will be initiated.

5.7.8.4.5 Corrective Actions to Control Excursions

Corrective action to retrieve an excursion will include adjusting the flow rates of the pumping and injection wells to increase the aquifer bleed in the area of the excursion. The sampling frequency will be increased to weekly. The NRC will be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions taken and the corrective action results will be submitted to NRC within 60 days of the excursion confirmation.

If wells are still on excursion status when the report is submitted, the report will also contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In accordance with NUREG-1569, p. 5-44, if an excursion is not corrected within 60 days of confirmation, Powertech (USA) will terminate injection of lixiviant into the affected portion of the well field until the excursion is retrieved, or provide an increase to the reclamation financial assurance obligation in an amount that is agreeable to NRC and that will cover the expected full cost of correcting and cleaning up the excursion. The financial assurance increase will remain in force until the excursion is corrected. The written 60-day excursion report will state and justify which course of action will be followed. If wells are still on excursion status

at the time the 60-day report is submitted to NRC, and the financial assurance option is chosen, the well field restoration financial assurance obligation will be adjusted upward. To calculate the increase in financial assurance for horizontal excursions, it will be assumed that the entire thickness of the confined operating horizon between the well field and the monitor well(s) on excursion contains lixiviant. The width of the excursion is assumed to be the distance between the monitor wells on excursion status plus one monitor well spacing distance on either side of the excursion. When the excursion is corrected, the additional financial assurance obligations resulting from the excursion will be removed.

5.7.9 Quality Assurance Program

After license issuance but prior to operations, Powertech (USA) will prepare a Quality Assurance Project Plan (QAPP) consistent with the recommendations contained in NRC Regulatory Guide 4.15 "*Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) -- Effluent Streams and the Environment*" (RG 4.15). The purpose of the QAPP is to ensure that all radiological and nonradiological measurements that support the radiological monitoring program are reasonably valid and of a defined quality. The QAPP is needed (1) to identify deficiencies in the sampling and measurement processes and report them to those responsible for these operations so that licensees may take corrective action and (2) to obtain some measure of confidence in the results of the monitoring programs to assure the regulatory agencies and the public that the results are valid.

The outline of the QAPP is provided in Figure 5.7-12.

Additionally, quality assurance recommendations contained in RG 4.14 and RG 8.22 will be incorporated in the environmental monitoring and bioassay programs, respectively. In general, the quality control requirements for a specific activity will be incorporated into the SOP for that activity.

The quality assurance program will be audited periodically. The audits will be conducted by individuals qualified in radiochemistry and monitoring techniques. However, the auditors will not have direct responsibilities in the areas being audited. An example of an appropriate auditor is a consultant. The results of the audits will be documented and made available to members of management with authority to enact any changes needed (i.e. RSO, Facility Manager, etc.).

Powertech (USA) Inc.

Dewey-Burdock Project
Quality Assurance Project Plan – Outline

1. Policy
2. Table of Contents
3. Introduction
   - 3.1 Purpose
   - 3.2 Scope
   - 3.3 Relationship to Other Plans
   - 3.4 Reference Documents
4. Regulatory Requirements
   - 4.1 Regulations
   - 4.2 Regulatory Guidance
5. Organization and Personnel
   - 5.1 Organizational Structure
   - 5.2 Personnel Responsibilities
   - 5.3 Personnel Qualifications
   - 5.4 Personnel Training and Certifications
6. Procedures and Instructions
7. Records and Recordkeeping
   - 7.1 Records Management Plan
   - 7.2 Record Retention Requirements
8. Sampling and Analysis
   - 8.1 Environmental Media
     - 8.1.1 Sampling Methods and Procedures
     - 8.1.2 Sample Containers, Preservation and Holding Times
     - 8.1.3 Field Measurements
     - 8.1.4 Decontamination Procedures and Materials
   - 8.2 Occupational Health and Safety Monitoring
9. Radionuclide Analysis
   - 9.1. Onsite Laboratory
   - 9.2. Contract Laboratory
10. Instruments and Equipment
    - 10.1 Calibration
    - 10.2 Maintenance
11. Data Management
    - 11.1 Data Validation
    - 11.2 Qualification of Data
    - 11.3 Anomalous Data
12. Assessment and Oversight
    - 12.1 Review and Improvement
    - 12.2 Assessment and Corrective Actions

Figure 5.7-12: Quality Assurance Project Plan Outline

5.7.10 References

Energy Metals Corporation, U.S., *"Application for USNRC Source Materials License Moore Ranch Uranium Project, Campbell County, WY";* Vol 1 Technical Report (2007).

NRCP Report No. 127, *"Operational Radiation Safety Program"*, (June 12, 1998).

USNRC Regulatory Guide 4.14, *"Radiological Effluent and Environmental Monitoring at Uranium Mills"*, (Revision 1, April 1980).

USNRC Regulatory Guide 4.15, *"Quality Assurance for Radiological Monitoring Programs (Normal Operations) – Effluent Streams and the Environment"*, (Revision 1, February 1979).

USNRC Regulatory Guide 8.13, *"Instruction Concerning Prenatal Radiation Exposure"* (Revision 3, June 1999).

USNRC Regulatory Guide 8.15, *"Acceptable Programs for Respiratory Protection"*, (Revision 1, October 1999).

USNRC Regulatory Guide 8.22, *"Bioassay at Uranium Mills"*, (Revision 1, August 1988).

USNRC Regulatory Guide 8.25, *"Air Sampling in the Workplace"*, (Revision 1, June 1992).

USNRC Regulatory Guide 8.29, *"Instruction Concerning Risks From Occupational Radiation Exposure"*, (Revision 1, February 1996).

USNRC Regulatory Guide 8.30, *"Health Physics Surveys in Uranium Recovery Facilities"*, (Revision 1, May 2002).

USNRC Regulatory Guide 8.31, *"Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as is Reasonably Achievable"*, (Revision 1, May 2002).

USNRC Regulatory Guide 8.36, *"Radiation Dose to the Embryo/Fetus"*, (July 1992).

6.0 Groundwater Quality Restoration, Surface Reclamation, and Facility Decommissioning

6.1 Plans and Schedules for Groundwater Quality Restoration

Groundwater restoration, reclamation of disturbed land and decommissioning of the well fields, plant and associated facilities will be conducted in a manner that will protect human health and the environment. The methods for achieving this objective are discussed in the following sections.

6.1.1 Groundwater Restoration Criteria

Groundwater restoration at the proposed project site will be performed pursuant to NRC requirements to protect underground sources of drinking water (USDW) adjacent to the site. Prior to recovery, a Class III Underground Injection Control (UIC) Permit that includes an aquifer exemption from the EPA must be issued. This exemption will be based on historical and existing water quality, the demonstration that the ore zone is commercially producible and that the ore zone has not historically nor will it now or in the future be an underground source of drinking water.

The groundwater restoration program for all well fields will be conducted pursuant to 10 CFR Part 40, Appendix A, Criterion 5, which sets forth groundwater quality standards for uranium milling facilities. Currently, Criterion 5 states that groundwater quality at such facilities shall have primary goals of baseline (background) or an MCL, whichever is higher, or an ACL. Powertech (USA) recognizes that an ACL is a site-specific, constituent-specific, risk-based standard that demonstrates that maintaining groundwater quality at the requested level at a designated point of compliance (POC) will be adequately protective of human health and the environment at the point of exposure (POE) and that groundwater quality outside the boundary of the aquifer exemption approved by EPA would meet background (baseline) levels or MCLs. Powertech (USA) understands that satisfaction of prior class-of-use can be proposed as a factor in demonstrating justification for an ACL.

Powertech (USA) understands that, in the event that the primary goal of groundwater restoration (i.e., baseline or an MCL, whichever is higher) cannot be met after engaging in all practicable (reasonably achievable) efforts, it will be required to submit an ACL application to NRC staff in accordance with its regulatory rights under 10 CFR Part 40, Appendix A, Criterion 5(B)(5). Powertech (USA) understands that any ACL application will be in the form of a license

amendment application that addresses, at a minimum, all of the relevant factors in 10 CFR Part 40, Appendix A, Criterion 5B(6), including but not limited to:

(a) Potential adverse effects on ground-water quality, considering—

(i) The physical and chemical characteristics of the waste in the licensed site including its potential for migration;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity of ground water and the direction of ground-water flow;

(iv) The proximity and withdrawal rates of ground-water users;

(v) The current and future uses of ground water in the area;

(vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground-water quality;

(vii) The potential for health risks caused by human exposure to waste constituents;

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(ix) The persistence and permanence of the potential adverse effects.

(b) Potential adverse effects on hydraulically-connected surface water quality, considering—

(i) The volume and physical and chemical characteristics of the waste in the licensed site;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity and quality of ground water, and the direction of ground-water flow;

(iv) The patterns of rainfall in the region;

(v) The proximity of the licensed site to surface waters;

(vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;

(vii) The existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality;

(viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and

(x) The persistence and permanence of the potential adverse effects.

Powertech (USA) intends to follow any and all relevant NRC guidance and policy in effect at the time that an ACL would be requested, including the NRC staff Technical Position on Alternate Concentration Limits for Title II Uranium Mills (NRC, 1996), which is the most current ACL guidance available to date.

Prior to operation, the baseline groundwater quality will be determined through the sampling and analysis of water quality indicator constituents in wells screened in the mineralized zone(s) across each well field. Section 5.7.8.3 describes the methods used to select baseline wells, sample the wells, and calculate baseline water quality statistics. The baseline samples will be analyzed for all parameters identified in Table 6.1-1. The target restoration goals (TRGs) will be established as a function of the average baseline water quality and the variability in each parameter according to statistical methods approved by NRC. The methods used to establish baseline water quality, identify outliers, evaluate variability, and calculate TRGs will be described within the well field hydrogeologic data package for each well field.

Table 6.1-1: Baseline Water Quality Parameter List

Test Analyte/Parameter*	Units	Analytical Method
Physical Properties		
pH ♯	pH units	A4500-H B
Total Dissolved Solids (TDS) +	mg/L	A2540 C
Conductivity	µmhos/cm	A2510 B
Common Elements and Ions		
Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Bicarbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B (as HCO_3)
Calcium	mg/L	E200.7
Carbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Chloride, Cl	mg/L	A4500-Cl B; E300.0
Magnesium, Mg	mg/L	E200.7
Nitrate, NO_3^- (as Nitrogen)	mg/L	E300.0
Potassium, K	mg/L	E200.7
Sodium, Na	mg/L	E200.7
Sulfate, SO_4	mg/L	A4500-SO4 E; E300.0
Trace and Minor Elements		
Arsenic, As	mg/L	E200.8
Barium, Ba	mg/L	E200.8
Boron, B	mg/L	E200.7
Cadmium, Cd	mg/L	E200.8
Chromium, Cr	mg/L	E200.8
Copper, Cu	mg/L	E200.8
Fluoride, F	mg/L	E300.0
Iron, Fe	mg/L	E200.7
Lead, Pb	mg/L	E200.8
Manganese, Mn	mg/L	E200.8
Mercury, Hg	mg/L	E200.8
Molybdenum, Mo	mg/L	E200.8
Nickel, Ni	mg/L	E200.8
Selenium, Se	mg/L	E200.8, A3114 B
Silver, Ag	mg/L	E200.8
Uranium, U	mg/L	E200.7, E200.8
Vanadium, V	mg/L	E200.7, E200.8
Zinc, Zn	mg/L	E200.8
Radiological Parameters		
Gross Alpha††	pCi/L	E900.0
Gross Beta	pCi/L	E900.0
Radium, Ra-226§	pCi/L	E903.0

*Analyte list based on NUREG-1569, Table 2.7.3-1. As noted on pg. 6 of NUREG-1569, Powertech (USA) may provide the rationale for the exclusion of water quality indicators/ parameters in a license application or amendment request if operational experience or site-specific data demonstrate that concentrations of constituents such as radium-228 are not significantly affected by ISR operations.

♯ Field and Laboratory

+ Laboratory only

††Excluding radon, radium, and uranium

§ If initial analysis indicates presence of Th-232, then Ra-228 will be considered within the baseline sampling program or an alternative may be proposed.

6.1.2 Estimate of Post-Production Groundwater Quality

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

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

Based on this review, the Crow Butte site was selected for the estimate because of the proximity and similar geologic conditions to the project site, available water quality data, reasonable pore volume estimates to achieve restoration and overall restoration success. The water quality data for the Crow Butte site is extensive with baseline, post-production, post-restoration, and stabilization period data. Baseline water quality, post-production water quality, post-restoration average water quality and stabilization period average water quality data are provided in Table 6.1-2 for the Crow Butte Mine Unit No.1. Powertech (USA) may expect similar baseline and post-production water quality results at the project site.

Table 6.1-2: Crow Butte Post Mining Water Quality Data Summary

Parameter	Baseline Water Quality	Post-Mining Water Quality	Post-Restoration Average Water Quality	Stabilization Period Average Water Quality
BULK PROPERTIES				
Specific Cond.	1947	5752	1620	1787
pH	8.5	7.35	7.95	8.18
TDS	1170.2	3728	967	1094
CATIONS/ANIONS				
Alkalinity	293	875	321	347
Chloride	204	583	124	139
Sulfate	356.2	1128	287	331
TRACE METALS				
Manganese	0.11	0.075	0.01	0.02
Arsenic	0.002	0.021	0.024	0.017
Iron	0.044	0.078	<0.05	0.09
Lead	0.031	<0.05	<0.05	<0.01
Uranium	0.092	12.2	0.963	1.73
Vanadium	0.066	0.96	0.26	0.11
RADIONUCLIDES				
Radium-226	229.7	786	246.7	303

Notes: All units in mg/L except for pH (standard units), radium (pCi/L), and specific conductivity (µmhos/cm).

6.1.3 Groundwater Restoration Methods

During aquifer restoration, Powertech (USA) will restore groundwater quality consistent with the groundwater protection standards contained in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis using best practicable technology. The technology selected will depend on the liquid waste disposal option as described below. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. In either case, Powertech (USA) proposes to remove at least six (6) pore volumes during aquifer restoration.

6.1.3.1 Deep Disposal Well Option

In the deep disposal well liquid waste disposal option, the primary method of aquifer restoration will be RO treatment with permeate injection. In this method, water will be pumped from one or more well fields to the CPP or Satellite Facility for treatment. Treatment will begin with removal of uranium and other dissolved species in IX columns. The water will then pass through the

restoration RO unit, which will remove over 90% of dissolved constituents using high pressure RO membranes. The treated effluent, or permeate, will be returned to the well field(s) for injection. The RO reject, or brine, will undergo radium removal in radium settling ponds and will then be disposed in one or more deep disposal wells.

The RO units will operate at a recovery rate of approximately 70%. Therefore, about 70% of the water that is withdrawn from the well fields and passed through the restoration RO unit will be recovered as nearly pure water, or permeate. In order to avoid excessive restoration bleed and consumptive use of Fall River and Chilson groundwater, permeate will be supplemented with clean makeup water from Madison Formation water supply wells. Permeate and Madison Formation water will be reinjected into the well field(s) at an amount slightly less than the amount withdrawn from the well field(s). This will be done to maintain a slight restoration bleed, which will maintain hydraulic control of the well field(s) throughout active aquifer restoration. The restoration bleed will typically be 1% of the restoration flow rate unless groundwater sweep is used in conjunction with RO treatment with permeate injection, in which case the restoration bleed will average approximately 17%. Refer to the “Optional Groundwater Sweep” discussion in Section 6.1.3.3.

6.1.3.2 Land Application Option

In the land application liquid waste disposal option, the primary method of aquifer restoration will be groundwater sweep with Madison Formation water injection. This method will begin the same as the method described above for RO treatment with permeate injection; water will be pumped to the CPP or Satellite Facility for removal of uranium and other dissolved species in IX columns. The partially treated water will undergo radium removal in radium settling ponds and will then be disposed in the land application system. Powertech (USA) refers to this portion of the aquifer restoration method as “groundwater sweep,” since none of the water recovered from the Fall River or Chilson will be reinjected into the well field(s).

RO will not be used if there are no deep disposal wells available to accept the RO brine. Instead, clean makeup water from the Madison Formation will be injected into the well field(s) at a flow rate sufficient to maintain the restoration bleed. As before, the restoration bleed will typically be 1% of the restoration flow rate unless the optional groundwater sweep method is used as described in Section 6.1.3.3.

The water quality of the Madison Formation is expected to be equal to or better than the baseline ore zone water quality, and injection of Madison Formation water will therefore be similar to injection of permeate under the deep disposal well option.

6.1.3.3 Optional Groundwater Sweep

Although a 1% restoration bleed will be adequate to maintain hydraulic control of well fields undergoing active aquifer restoration, additional bleed may be required at times. For example, additional restoration bleed may be used to recover flare of lixiviant outside of the well field pattern area. In addition to the restoration methods described above, Powertech (USA) may withdraw up to one (1) pore volume of water through groundwater sweep over the course of aquifer restoration. This will result in an average restoration bleed of approximately 17%.

6.1.3.4 Flare Control and Capture

Flaring will be controlled by maintaining balanced well fields and adequate bleed during uranium recovery and aquifer restoration. Powertech (USA) will maintain hydraulic control of each well field from the first injection of lixiviant through the end of active aquifer restoration. During uranium recovery, the groundwater removal rate in each well field will exceed the lixiviant injection rate, creating a cone of depression within the well field. During aquifer restoration, the groundwater removal rate in each well field will exceed the injection rate of permeate and clean makeup water from the Madison Formation. If there are any delays between uranium recovery and aquifer restoration, production wells will continue to be operated as needed to maintain water levels within the perimeter monitor rings below baseline conditions. This activity may be intermittent or continuous.

Verification of hydraulic control will be performed through water level measurements in perimeter monitor wells. Water levels will be measured continuously using pressure transducers and recorded at a frequency appropriate to confirm hydraulic well field control.

Flaring will be captured by maintaining adequate restoration bleed. If necessary, the restoration bleed may be increased to provide up to one (1) pore volume of groundwater sweep as discussed above. The results of a numerical modeling potential impact analysis for the Inyan Kara under aquifer restoration with and without one (1) pore volume of groundwater sweep are provided in Appendix 6.1-A.

6.1.4 Restoration Schedule

The proposed project schedule, Figure 6.1-1, shows the estimated schedule for restoration. This is a preliminary schedule based on current knowledge of the area, and is based on completion of the production activities for both the Dewey and Burdock sites. As the project is developed, the restoration schedule will be further refined. As illustrated on Figure 6.1-1, it is expected that the aquifer restoration phase for each well field will be completed in less than two years. Powertech (USA) will notify the NRC in writing, in accordance with 10 CFR 40.42, within 60 days of the cessation of recovery operations in any individual well field. Should restoration efforts indicate a period longer than 24 months is necessary for groundwater restoration of a particular well field, Powertech (USA) will request NRC approval for an alternate schedule in accordance with 10 CFR 40.42.

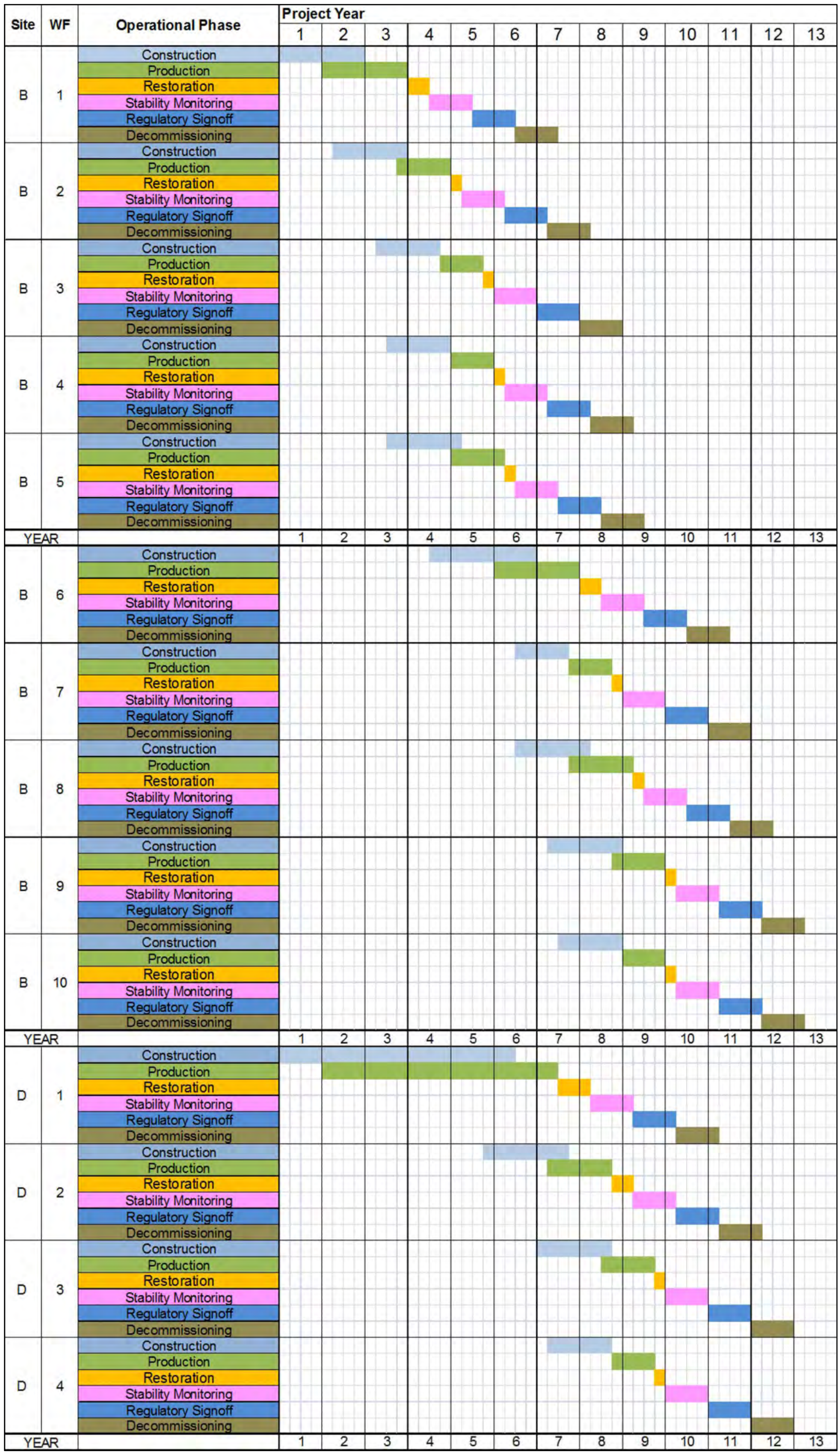


Figure 6.1-1

Proposed Project Operations and Restoration Schedule

Dewey-Burdock Project

DRAWN BY J. Mays

DATE 18-Jun-2013

FILENAME OpRestSched.dwg

POWERTECH (USA) INC.

6.1.5 Effectiveness of Ground Water Restoration Techniques

The preferred aquifer restoration method is RO treatment with permeate injection. This is the aquifer restoration method that will be used if deep disposal wells are used to dispose liquid waste. As described in Section 2.5.3 of the ISR GEIS (NUREG-1910), this method of aquifer restoration is responsible for returning "total dissolved solids, trace metal concentrations, and aquifer pH to baseline values." RO treatment with permeate injection has proven effective at achieving successful aquifer restoration as described below.

> "Results of the effectiveness of groundwater sweep (or lack of it) were clearly demonstrated in the Christensen Ranch Wellfield Restoration report (CRWR) (COGEMA 2008). Example plots from that report of mean well field water quality at the end of mining, groundwater sweep, RO and stabilization monitoring… indicate minimal improvement following groundwater sweep at MU3 and MU5 and an actual increase [in dissolved constituents] at MU6. Following application of RO, the TDS values at MU5 and MU6 decreased to levels below the target Restoration Goal. Uranium increased in MU5 and MU6 following groundwater sweep…and then was significantly lowered during RO. Approximately 1.8, 4.8 and 1.5 PVs of groundwater were removed from MU3, MU5 and MU6, respectively, during groundwater sweep. This water removal was totally consumptive by design, in that none of it was returned to the aquifer.
>
> "Based on the results, minimal benefit, if any, was derived from [the groundwater sweep] phase of restoration. Eliminating groundwater sweep, an unnecessary, ineffective and consumptive step in the restoration process, will reduce the number of PVs required to reach restoration goals.
>
> "Terminating RO once water quality has stabilized will minimize the consumptive use of groundwater and reduce the number of PVs of treatment." (Uranium One, 2008)

The following analogues demonstrate the effectiveness of RO treatment with permeate injection as an effective aquifer restoration technology:

The Ruth R & D Project was a Wyoming pilot test conducted by Uranerz USA, Inc. in the early 1980s. The ore body represented a typical roll front type deposit with the target ore zone approximately 500 feet below ground surface. Groundwater restoration began in February 1984. Groundwater sweep was initially the primary restoration method, but it was terminated due to excessive water consumption. Groundwater restoration continued using RO treatment with permeate injection. By September 1984, TDS was successfully lowered, but the concentrations of a few metals remained above target restoration goals. A reductant phase was initiated in November 1984 and continued for six weeks. This combination of treatment was deemed

successful, and by the end of December 1984 restoration activities were terminated. At the end of the stability period, regulatory agencies deemed the water quality was stable and aquifer restoration efforts by Uranerz were successful. (Catchpole and Kuchelka, 1993)

The Crow Butte R&D Project also used RO treatment with permeate injection to achieve successful aquifer restoration. According to Catchpole and Kuchelka (1993), RO treatment with permeate injection "restored the quality of the groundwater in the mined out well field to a level acceptable to the agencies and, following the successful completion of the six month stability monitoring period, the agencies deemed that Ferret Exploration Company of Nebraska had demonstrated the capability of restoring an aquifer affected by ISR mining operations."

The Bison Basin Commercial ISL Uranium Mine is another example of a successful restoration project using RO treatment with permeate injection. According to Catchpole and Kuchelka (1993), "This action returned all water quality parameters to levels acceptable to the regulatory agencies and, following the successful completion of a 12 month stability monitoring period, the aquifer was deemed restored. The Bison Basin case represented the first successful aquifer restoration of a commercial sized ISL well field in the United States."

As described in Section 6.1.3, clean makeup water from the Madison Formation will be used to supplement permeate and maintain the restoration bleed in the deep disposal well option. In the land application option, all of the water reinjected into the well fields during active aquifer restoration will come from the Madison Formation. The water quality of the Madison Formation is expected to be equal to or better than the baseline ore zone water quality, and injection of Madison Formation water will therefore be similar to injection of permeate under the deep disposal well option.

Refer to Section 6.1.3.3 for a discussion of the optional groundwater sweep that Powertech (USA) may use with either the deep disposal well or land application options. In order to recover flare of lixiviant outside the well field pattern area, up to one (1) pore volume of groundwater sweep may be employed over the course of aquifer restoration.

6.1.6 Pore Volume Calculations and Restoration Pore Volumes

The formulas for determining the pore volume and the volume of restoration composite (RC) to be withdrawn during aquifer restoration are as follows:

Pore volume = (well field pattern area) x (thickness) x (porosity) x (flare factor)

RC volume = (pore volume) x (number of pore volumes for aquifer restoration)

The thickness is the average thickness of the mineralized zones as determined by down-hole radiological logging. The average thickness in the Dewey-Burdock project area is 4.6 feet. Pore volumes will be calculated based on the actual screen lengths of injection and production wells and not by the ore zone thickness.

The porosity of the ore zone within the project area was determined by laboratory analysis of core samples. Based on 11 measurements of ore zone porosity from core samples of the Fall River and Chilson host sands, the average porosity of the ore zone sands within the project area is 0.30.

The proposed flare factor is 1.44, accounting for both horizontal and vertical flare of lixiviant during ISR operations. Support for the flare factor is contained in the numerical groundwater modeling results presented in Appendix 6.6-B, "Numerical Modeling of Groundwater Conditions Related to In situ Recovery at the Dewey-Burdock Uranium Project, South Dakota." Appendix 6.6-B describes how horizontal flare from a modeled balanced well field was determined to be 1.19. Vertical flare is expected to be similar to or less than the horizontal flare since the horizontal conductivity is greater than vertical conductivity. An overall flare factor of 1.44 is supported by the numerical modeling results presented in Appendix 6.6-B.

The flare factor and number of pore volumes required for aquifer restoration are both a function of the properties of the particular sandstone formations and ore deposits, as well as the operational factors of aquifer bleed rates, the balancing of pattern flow rates, the use of RO during aquifer restoration and the timeliness of beginning aquifer restoration operations following cessation of recovery operations. For the Dewey-Burdock Project, the values of the flare factor and the number of pore volumes removed for aquifer restoration are comparable to those that have been recently approved for other ISR facilities and are consistent with the best practicable technology for aquifer restoration.

The overall (horizontal and vertical) flare factor for ISR uranium projects has varied from 1.44 at Irigaray/Christensen Ranch (COGEMA, 2008 and COGEMA, 2005) to 1.95 at Churchrock/Crownpoint (HRI, 2001). The overall well field flare factor for the Dewey-Burdock Project is estimated to be 1.44, which is equal to the flare factor in approved license applications at ISR facilities located nearby in the State of Wyoming and is supported by numerical groundwater modeling.

The number of pore volumes, including flare, of groundwater to be removed to achieve aquifer restoration is estimated to be 6.0. This figure is consistent with the best practicable technology that includes the following operational practices:

(i) Daily balancing of injection and extraction flow rates during production. This flow rate balancing is designed to ensure that a proper aquifer bleed is maintained both at the well field level and also within each 5-spot pattern within the well field.
(ii) Timeliness of beginning restoration operations. For any particular well field, aquifer restoration operations will begin as soon as is reasonably possible following the cessation of recovery operations.
(iii) Maintenance of aquifer bleeds. Hydraulic control of well fields through the net withdrawal of the aquifer bleed stream will be continuously maintained from the beginning of recovery operations until the end of active aquifer restoration.

While the number of pore volumes required for aquifer restoration has historically proven to have been significantly higher for some of the early ISR uranium projects, the methods and timing of restoration likely contributed to these larger numbers. The following information was obtained from the Moore Ranch license application (Uranium One, 2008)

> "The average number of PVs extracted and treated/reinjected/or disposed was 13.6 for Irigaray and 12.4 for Christensen … Circumstances at both those ISR projects resulted in increased PVs to achieve restoration goals including the following:
>
> - Production and restoration were not conducted sequentially, and were plagued with extended periods of shut-in and standby, with delays of up to several years in some cases;
> - Groundwater sweep, the initial phase of restoration, was often largely ineffective and in some cases may have exacerbated the problem; and
> - RO was continued in some well fields after it was apparent that little improvement in water quality was occurring.
>
> "Restoration was not performed immediately following the completion of production, and in some cases, there were long periods of inactivity during the production and restoration phases. At Irigaray, production was interrupted for a period of almost six years in MU1 through MU5 … Similarly, there was a three-year break in production in MU6 through MU9, when the operation was in standby status. Restoration did not commence at MUl through MU3 until a year after production had ended. At MU4 and MU5, restoration operations did not begin until two years following production. Restoration commenced shortly after the end of production at MU6 through MU9. However the project was on standby status between the completion of groundwater

> sweep and the beginning of the RO phase of production, resulting in a break of one to two years, depending on the MU. Restoration was initiated sooner after the end of production at Christensen Ranch, with the exception of MU3 and MU4. However, there were periods of standby between groundwater sweep and RO treatment/injection of up to a year. These delays between and during production and restoration operations most likely increased the number of PVs required to complete aquifer restoration."

For the financial assurance calculations, the pore volume affected in the first year of production is estimated to be approximately 13 million gallons, corresponding to an active well field area of approximately 20 acres. The restoration composite, or volume of groundwater to be extracted during groundwater restoration, is estimated to be approximately 78 million gallons. Calculations are presented in Appendix 6.6-A.

6.1.7 Environmental Effects of Groundwater Restoration

Based on the success of groundwater restoration at other ISL facilities, Powertech (USA) expects that the proposed groundwater restoration techniques will be successful at returning the production zones within the PAA to restoration target values. The purpose of restoring the groundwater to these indicator parameters is to protect USDWs adjacent the aquifer exemption boundary. Powertech (USA) believes that by using proven best practicable technology for groundwater restoration combined with federal and state regulatory requirements will ensure that potential impacts to groundwater quality outside the production zone are mitigated.

The preferred method of restoration consists of using the groundwater treatment method with RO reject brines being treated for radium removal and disposed in Class V disposal wells. This method minimizes the amount of groundwater that will be consumed during restoration, and minimizes the surface disturbance to land within the permit boundary. Disposal of wastewater in deep disposal wells is the best practicable technology and is the standard method used at most ISL uranium mines. The alternate method of land application would consume more groundwater since none of the restoration water would be recycled to the well field, but would be used in a once-through process leading to land application.

The proposed restoration methods will consume groundwater. Groundwater recovered during groundwater restoration is typically disposed of directly in the wastewater system. Consumption of groundwater is an unavoidable consequence of groundwater treatment; potential impacts and water usage during operations is discussed in more detail in Section 7.2.5.1.

6.1.8 Groundwater Restoration Monitoring

6.1.8.1 Monitoring During Active Restoration

During active aquifer restoration, monitoring wells will be sampled every 60 days and analyzed for the indicator UCL parameters. If the concentration of two of the three excursion indicators exceeds the UCL concentrations during a sampling event, a subsequent sample will be taken within 24 hours and analyzed for the excursion indicators. If the confirmatory sample results are not complete within 30 days then for reporting purposes (described below) the excursion is considered confirmed. If the second sample does not confirm an excursion a third sample will be taken within 48 hours. If two or more excursion indicators of either the second or third samples exceed the UCL concentrations for the excursion indicators, the well in question will be placed on excursion status and corrective action will be taken. The first sample will be considered an error if neither the second nor third sample confirm the first sample results.

Corrective Action and Monitoring

Corrective actions following the confirmation of an excursion will include: sampling frequency will be increased to weekly; pumping rates of production wells in the area of the excursion will increase; the net bleed will be increased; individual wells will be pumped to enhance recovery of ISR solutions; and an excursion report will be prepared for NRC. If actions taken are not effective at retrieving the excursion within 60 days, Powertech (USA) will suspend injecting lixiviant into the production zone adjacent to the excursion until the excursion is retrieved and the UCL parameters are not exceeded.

Notification

In the event of an excursion Powertech (USA) will notify the NRC within 24 hours by telephone or email, and in writing within 30 days, and begin corrective actions.

Monitoring the Progress of Active Restoration

Powertech (USA) will implement an active aquifer restoration monitoring program to document the progress of aquifer restoration. During active aquifer restoration, each well field will be monitored on a frequency sufficient to determine the success of aquifer restoration, optimize the efficiency of aquifer restoration and determine if any areas of the well field need additional attention. At the beginning of aquifer restoration, water level will be measured and groundwater analyzed for all parameters listed in Table 6.1-1 for the subset of production zone sampling wells used in baseline. Thereafter, samples will be collected and analyzed for all or selected parameters as needed.

The success of aquifer restoration will be demonstrated during the well field stabilization period.

The results of the active restoration monitoring will be used to evaluate potential areas of flare or hot spots. If potential flare or hot spots are identified, appropriate corrective measures will be taken. These may include adjusting the flows in the area, changing wells from injection to production or vice-versa, or adjusting the restoration bleed in specific areas. Additional information on statistical methods used to identify hot spots is provided in Section 6.1.8.2.

6.1.8.2 Restoration Stability Monitoring

A groundwater stability monitoring period will be implemented to show that the restoration goal has been adequately maintained. The stability monitoring period will consist of twelve (12) months with quarterly sampling. Over the 12-month minimum stability monitoring period, there will be at least five (5) sample events, including one at the beginning of the stability monitoring period and following each of the following four quarters. The criteria to establish restoration stability will be based on well field averages for water quality, except that hot spots will be evaluated based on the results from individual wells.

During the restoration stability period, the following monitoring program will be utilized:

Monitoring wells in the perimeter ring and those wells in the overlying and underlying aquifers will continue to be sampled once every 60 days for the UCL indicator parameters of chloride, total alkalinity (or bicarbonate), and conductivity. The NRC will be contacted if any of the wells cannot be sampled within 65 days of the last sampling event due to unforeseen conditions such as snowstorms, flooding, or equipment malfunctions.

Quarterly, the production-zone wells that were sampled to determine well field baseline will be sampled and analyzed for the water quality parameters listed in Table 6.1-1. The criteria to establish successful stability will be that, for each sampling event, the mean constituent concentration of each water quality parameter meets the target restoration goal established for that parameter from baseline sampling, as described in Section 5.7.8.3.

Linear regression analysis will be performed on each monitored constituent measured in the production zone baseline wells. This statistical method will assist in determining if the concentration of a given constituent exhibits a significantly increasing trend during the stability period. If a constituent exhibits a strongly increasing trend, or in the case of pH a strongly increasing or decreasing trend, Powertech (USA) will take action to resolve the situation. The

action taken will depend on the constituent and the status of the restored groundwater system. Due to the complexity of the aqueous geochemical groundwater systems involved, these statistical techniques will not be relied on as the sole determinant when evaluating the effectiveness of groundwater restoration. Therefore, Powertech (USA) will consider which constituent(s) shows an increasing trend in concentration and base the decision on further action on the status of the production zone groundwater geochemistry. These actions may include extending the stability period or returning the well field to a previous phase of active restoration to resolve the issue. The phase of active restoration that will be used will be determined by the constituent and the process required to bring it to stability.

If the analytical results from the stability period continue to meet the target restoration goals and do not exhibit significant increasing trends, then Powertech (USA) will submit supporting documentation to the regulatory agencies showing that the restoration parameters have remained at or below the restoration standards and will request that the well field be declared restored.

For one or two parameters, localized, elevated concentrations above the restoration criteria may remain in the production zone following restoration. These isolated, residual elevated concentrations are referred to as “hot spots.” The primary indicator of a hot spot for a specific constituent or parameter will be the mean production zone concentration plus two standard deviations. For pH, the indication of a hot spot will be plus or minus two standard deviations. If a constituent or parameter at a production zone baseline sampling well exceeds that criterion during the stability period, the location of the well will be identified as a hot spot. Once a hot spot is identified, additional evaluation will be conducted to determine potential impacts that such a hot spot could have on water quality outside of the exempted aquifer. The additional evaluation may include collection of additional water samples, analysis of added parameters, trend analysis, or flow and transport modeling. Based on the results of the evaluation, additional stability monitoring or restoration may be conducted as needed to ensure the protection of water quality outside the exempted aquifer. If hot spots are sufficiently demonstrated not to have the potential to affect water quality outside of the exempted aquifer and the restoration criteria are otherwise met without increasing trends, then no additional action will be taken and Powertech (USA) will submit supporting documentation to the regulatory agencies showing that the restoration parameters have remained at or below the restoration standards and will request that the well field be declared restored.

6.1.9 Well Plugging and Abandonment

Prior to plugging, each well will undergo mechanical integrity testing (MIT) to demonstrate the integrity of casing and cement that will be left in the ground after closure. Alternatively, cementing records or other evidence (such as cement bond logs) will be used to show that an adequate quantity of cement is present to prevent upward fluid movement within the borehole outside of the casing.

Powertech (USA) will plug all wells with bentonite or cement grout. The weight and composition of the grout will be sufficient to control artesian conditions and meet the well abandonment standards of the State of South Dakota, including Chapter 74:02:04:67 (Requirements for Plugging Wells or Test Holes Completed into Confined Aquifers or Encountering More than One Aquifer) of the South Dakota Administrative Rules. Cementing will be completed from total depth to surface using a drill pipe. Records will be kept of each well cemented including at a minimum the following information:

- well ID, total depth, and location
- driller, company, or person doing the cementing work
- total volume of cement placed down hole
- viscosity and density of the slurry used

Powertech (USA) will remove surface casing and set a cement plug to a depth 6 ft below the ground surface on each well or borehole plugged and abandoned.

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6.1.10 Restoration Wastewater Disposal

As noted earlier, the method of wastewater disposal is closely linked to the choice of groundwater restoration methods. The preferred option is to dispose of wastewater by injection into Class V disposal wells. The alternate option is land application of treated wastewater. Additional details and water balance figures are provided in Section 4.2.

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6.1.11 References

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COGEMA, 2008, Wellfield Restoration Report, Christensen Ranch Project, Prepared by COGEMA Mining, Inc. and Petrotek Engineering Corporation, March 5, 2008, NRC ADAMS Accession No. ML081060131.

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NRC, 1996, NRC Staff Technical Position: Alternate Concentration Limits for Title II Uranium Mills, January 1996.

Uranium One, 2008, Responses to NRC Request for Additional Information, Moore Ranch Uranium Project Source Material License Application, October 2008, NRC ADAMS Accession No. ML090370542.

6.2 Plans and Schedules for Reclaiming Disturbed Lands

At the completion of the project, all disturbed lands will be returned to their pre-production land use of livestock grazing and wildlife habitat. The objective of the surface reclamation effort is to return the disturbed lands to equal or better condition than pre-production. All buildings and structures will be decontaminated to regulatory standards and demolished and trucked to an approved disposal facility. Baseline soils, vegetation, and radiological data will be used as a guide in evaluating the final reclamation. A final decommissioning plan will be submitted to the NRC for review and approval at least 12 months prior to the planned decommissioning of a well field or PAA.

6.2.1 Pre-Reclamation Radiological Surveys

Consistent with NUREG-1569, Acceptance Criterion 6.2.3(2), Powertech (USA) will implement a pre-reclamation radiological survey program to identify areas for cleanup operations. The instruments and techniques for pre-reclamation radiological surveys to identify areas of the site that need to be cleaned up to comply with NRC concentration limits will be the same or similar to those used to survey the project area for pre-operational radiological conditions. The instruments used for the pre-operational survey are described in Section 2.9 and include unshielded Ludlum Model 44-10 2" x 2" sodium iodide (NaI) detectors coupled to Ludlum Model 2221 rate meter/scalers (set in rate meter mode) and a Trimble Pro XRS GPS receiver with Trimble TSCe data logger.

Consistent with NUREG-1569, 6.2.1 Areas of Review, Powertech (USA) will provide the NRC and SD DENR with maps and data that document the post-operational condition. The techniques to be used during the pre-reclamation radiological survey include putting special emphasis on those areas with the highest potential for surface contamination, including diversion ditches, surface impoundment areas, well fields (particularly those areas where potential spills or leaks may have occurred), process structures, storage areas, on-site transportation routes for contaminated material and equipment, and areas associated with liquid waste disposal. Powertech (USA) will also consider results from operational monitoring and any other information that provides insight to areas with the greatest potential to be contaminated. Powertech (USA) will use a sampling grid of 100 m^2 for soil and other specifications to ensure that radium and other radionuclides will not exceed the standards in 10 CFR Part 40, Appendix A, Criterion 6(6). Guidance for sample size and other techniques provided in NUREG-1575 will be used as reference for the pre-reclamation radiological survey.

The following general procedures for interpretation of the pre-reclamation survey results will be used to identify areas for cleanup operations:

1) Pursuant to 10 CFR Part 40, Appendix A, Criterion 6(6), the radium-226 content in soils, averaged over areas of 100 m^2, will not exceed the background concentration by more than (i) 5 pCi/g of Ra-226 averaged over the first 15 cm (5.9 in) below the surface, and (ii) 15 pCi/g of radium-226 averaged over 15 cm thick layers more than 15 cm below the surface.

2) The background radionuclide concentrations have been determined using appropriate methods as described in Section 2.9. There are two areas within the project area where the gamma survey recorded levels higher than the majority of the project area. These are the surface mine area in the northeast portion of the project area and a naturally anomalous area in the northern portion of the project area. These areas may warrant a different background concentration. Should Powertech (USA) determine that use of a different background radionuclide concentration is warranted, it will propose one with its final decommissioning plan.

3) For areas that meet the radium cleanup criteria, but that still have elevated thorium-230 levels, Powertech (USA) proposes to provide in its final decommissioning plan an acceptable cleanup criterion for thorium-230, one that when combined with residual concentrations of radium-226, would result in the radium concentration (both radium residual and from thorium decay) that would meet the radium cleanup standard in 1,000 years.

4) Likewise, Powertech (USA) will propose acceptable criteria for uranium in soil, such as those found in Appendix E of NUREG-1569.

5) Lastly, the survey method for cleanup operations will be designed to provide 95% confidence that any residual radionuclides on the project area will be identified and cleaned up. Powertech (USA) will apply appropriate statistical tests for analysis of survey data.

6.2.2 Surface Disturbance

Due to the nature of ISL production, minimal and intermittent surface disturbance will be associated with the project, and will be mainly associated with the CPP, maintenance and office areas. Additional intermittent disturbance occurs in the well fields, which includes well drilling, pipe installations, and road construction; however, disturbances associated with the well field impact a relatively small area and have short-term impacts.

Surface disturbances associated with the construction of the CPP, office and maintenance buildings, and well field header houses will be for the life of those activities. Topsoil will be stripped and stockpiled from these areas prior to construction. Disturbances associated with the well field drilling and pipeline installation are limited and will be reclaimed as soon as possible after these components are completed. Surface disturbance associated with the development of access roads will occur at the project site; topsoil will be stripped from the road areas and stockpiled prior to construction.

While, the PAA encompasses 10,580 acres, the land potentially disturbed by the PAA will be approximately 68 acres (facilities, piping, ponds, well fields and roads) the year proceeding operation.. The disturbed area during the life of the project (production to restoration) is estimated to increase over time to a maximum of 108 acres. The maximum potential disturbance at any given time is expected to be 463 acres.

6.2.3 Topsoil Handling and Replacement

Topsoil will be salvaged from any building sites, permanent storage areas, access roads, and chemical storage areas prior to construction in accordance with SD DENR requirements. Typical earth moving equipment such as rubber tired scrapers and front end loaders will be used for topsoil stripping. In the well field, topsoil removal will be limited to headerhouse locations and access roads. A total of an estimated 13 acres of topsoil will be stripped, stockpiled, and replaced during the life of the project.

Salvaged topsoil will be stored in designated topsoil stockpiles. These stockpiles will be located such that losses from wind erosion are minimized. Additionally, topsoil stockpiles will not be located in any drainage channels or other locations that could lead to a loss of material. Berms will be constructed around the perimeter of stockpiles and the stockpile will be seeded with an approved seed mix to help minimize sediment runoff. Additionally, all topsoil piles will be identified with highly visible signs per SD DENR requirements.

During excavations of mud pits associated with well construction, exploration drilling, and delineation drilling activities, topsoil is separated from the subsoil with a backhoe. First the topsoil is removed and placed at a separate location and then the subsoil is removed and deposited next to the mud pit. Usually within 30 days of the initial excavation use of the mud pit is complete; the subsoil is redeposited in the mud pit followed by the replacing of topsoil. Pipeline ditch construction follows a similar procedure storing topsoil and subsoil separately and depositing the topsoil on the subsoil after the ditch has been backfilled.

6.2.4 Final Contouring

Due to the nature of ISL production, there will be very few construction activities that will require any major contouring during reclamation. Surface disturbances that do occur will be contoured to blend in with the natural terrain. Since no major changes in the topography will result from the proposed action, a final contour map has not been included.

6.2.5 Revegetation Practices

Revegetation practices will be conducted in accordance with NRC and DENR regulations and the methods outlined in the SD DENR mining permit. In order to help reduce wind and water erosion, topsoil stockpiles and other various disturbances in the well field area will be seeded throughout the PAA. Per SD DENR regulations, the seed mix will be chosen to be compatible

with the post-production land use. The local conservation district, landowners and the SD DENR will be consulted when selecting the seed mix.

A reference area may be used to measure the success of reclamation. The reference area will be selected in a location that will not be affected by future production and is representative of the post-production land use. It will be managed such that there are no significant changes in cover, productivity, species diversity and composition of the vegetation.

Seeding may be done with a rangeland drill or with a broadcast seeder where practical. After topsoil preparation is completed affected lands will be seeded during the first normal period of favorable planting conditions unless an alternative plan has been approved. Any gullies or rills that would preclude the successful establishment of vegetation or achievement of the post-production land use will be removed or stabilized as part of the revegetation and reclamation process.

6.3 Procedures for Removing and Disposing of Structures and Equipment

The procedures for removing and disposing of structures and equipment include the establishment of surface contamination limits, preliminary radiological surveys of process building surfaces, equipment and piping systems; strategic cleanup and removal of process building materials and equipment, sorting materials according to contamination levels and salvageability, and preparing materials for transport and offsite use or disposal. Although not mentioned hereafter, the procedures also apply to tools and other equipment, such as backhoes.

All decommissioning activities will be done in accordance with the NRC license, Titles 10 and 49 of the CFR, and other applicable regulatory requirements.

6.3.1 Establishment of Surface Contamination Limits

Powertech (USA) will use surface contamination release limits contained in Enclosure 2 to Policy and Guidance Directive FC-82-23 (as updated) to release material and equipment that has potentially come into contact with licensed material.

Surface contamination release limits for surfaces on structures intended for unrestricted release following decommissioning are subject to Criterion 6(6) of Appendix A to 10 CFR 40. Acceptable dose-based surface contamination release limits will be established using the RESRAD-Build model or an equivalent model and will be provided in the final Decommissioning Plan, which will be submitted 12 months prior to any planned decommissioning. In the Decommissioning Plan, Powertech will assume that all premises, equipment, or scrap likely to be contaminated in excess of limits, but that cannot be measured, is contaminated in excess of limits and will be treated accordingly.

6.3.2 Preliminary Radiological Surveys and Contamination Control

Powertech (USA) will develop one or more characterization plans that it will follow to demonstrate compliance with the surface contamination limits for building materials, systems, and equipment. The characterization plan(s) will include guidance and SOPs to conduct the preliminary surveys and control contamination. Powertech (USA) will prepare procedures for performing radioactivity measurements on the interior surfaces of pipes, drain lines, and ductwork, and include the procedures in the Decommissioning Plan. Such plans will include measurements at all traps and other access points where contamination is likely to be representative of system-wide contamination.

Areas within buildings showing evidence of possible penetration of process solutions will be evaluated for possible subsurface contamination. If building materials, slabs and soils beneath the slabs are not contaminated, the buildings shall be released for unrestricted use, provided the building surfaces meet the release criteria and radiological monitoring requirements of the characterization and verification plans. Otherwise, the buildings will be demolished, the slabs removed, and the underlying soils removed (if contaminated). All materials contaminated above release limits will be prepared for offsite disposal at a licensed disposal facility. Contamination control will be addressed using operational SOPs, in conjunction with radiological surveys.

Concrete slabs will be surveyed and if found to contain radionuclides in excess of the release limits, an attempt will be made to decontaminate the concrete slab(s). If after a second survey radionuclides are in excess of the release limits, the concrete will be broken up and disposed of at a licensed 11e.(2) disposal site. If the survey results indicate that the concrete is not contaminated above release limits, it may be disposed in an appropriately permitted landfill, used for fill elsewhere, or left in place for use by the landowner.

6.3.3 Removal of Process Building and Equipment

Powertech (USA) will develop plans for the strategic removal of process building and equipment, based on inventory, the results of the radiological surveys, decontamination options and available methods, reuse/disposal pathways, and information obtained during the effort. To the extent possible, Powertech (USA) intends to decontaminate salvageable equipment for unrestricted release. Decontamination methods may include a combination of washing, high pressure sprays, or steam cleaning. Cleaned surfaces will be air-dried prior to radiological monitoring. The ALARA principle applies to decommissioning activities. As such, surface contamination will be reduced to levels as far below applicable limits as practical.
Powertech (USA) will document the results of radiological surveys for all building materials, systems, and equipment. These items will be sorted as follows:

- Salvageable and contaminated above release limits (not releasable but potentially disposable or transferrable)
- Salvageable and contaminated below release limits (releasable) for unrestricted use
- Not salvageable and contaminated above release limits (offsite disposal at a facility licensed to accept 11e.(2) byproduct material)

- Not salvageable and contaminated below release limits (offsite disposal at a permitted facility)

In the first case, the item may be transferred to another NRC or Agreement State licensee. If it cannot be transferred or decontaminated to be released for unrestricted use, it will be disposed of at a licensed disposal facility. In all cases, Powertech (USA) will strictly maintain an inventory of all process building and equipment and the results of radiological surveys.

6.3.3.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Powertech (USA) will develop an approved standard operating procedure for release of items to unrestricted use and thoroughly document all items eligible for release to unrestricted use. To the extent possible, releasable items having a salvageable value will be sold on the industrial market. Releasable items having no net salvageable value will be sent to a municipal landfill.

6.3.3.2 Preparation for Disposal at a Licensed Facility

All materials and plant equipment unsuitable for unrestricted release will be prepared for offsite disposal at a licensed facility. Building materials, tools, and equipment destined for offsite disposal will be prepared for transportation and disposal in accordance with 49 CFR and other applicable requirements.

6.3.4 Waste Transportation and Disposal

Waste transportation will be performed in accordance with 49 CFR and all other applicable regulations. Offsite shipments will be properly prepared, in terms of packaging, marking and labeling, dose rate measurements, shipping papers, and emergency contact information. Offsite disposal will be conducted in accordance with disposal facility licensing requirements, including waste characterization and profiling.

Powertech (USA) will maintain a strict inventory of materials sent for disposal in a municipal landfill, i.e., those that are both non-salvageable and meet the requirements of unrestricted release. In all cases, Powertech (USA) will couple the ultimate destinations of all items to its origin, date of generation, and the results of radiological surveys.

6.3.5 Plans for Decommissioning Non-Radiological Hazardous Constituents

Consistent with NUREG-1569 and 10 CFR Part 40, Appendix A, Criterion 6(7), Powertech (USA) will ensure that non-radiological hazards are addressed in the planning and implementation processes of decommissioning and closure. Section 1.10 includes a discussion of non-radiological wastes and their disposition at closure. Non-radiological cleanup concerns related to the land application option are addressed in Section 7.3.3.8.2.

Any non-radiological hazardous waste that is determined to be 11e.(2) byproduct material will be disposed of offsite at a licensed 11e.(2) waste disposal site in accordance with NRC's directive in 10 CFR Part 40, Appendix A, Criterion 2. Any non-radiological hazardous waste that is not 11e.(2) byproduct material will be disposed offsite at a permitted hazardous waste disposal facility. As described in Section 1.10, potentially hazardous liquid wastes such as used oil, hydraulic fluid, cleaners, solvents and degreasers will be recycled or disposed offsite at an appropriately permitted hazardous or solid waste disposal facility. In addition, as described in Section 7.3.3.8.2, residual non-radiological metal concentrations in land application areas are not expected to exceed their respective EPA soil screening levels (SSLs). Powertech (USA) will include more details on decommissioning non-radiological hazardous constituents in its final decommissioning plan, which will be submitted 12 months prior to any planned reclamation.

6.4 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

6.4.1 Cleanup Criteria

Powertech (USA) will conduct land cleanup in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and South Dakota DENR regulations. Powertech (USA) commits to removal of all 11e.(2) byproduct material for disposal in a licensed 11e.(2) disposal facility (including all affected soils, liners, equipment, filters, etc.) or, if liquid, using an appropriately permitted deep disposal well and/or land application. Any non-11e.(2) byproduct material will be disposed off-site in an appropriately permitted solid or hazardous waste disposal facility.

Surface soils will be cleaned up in accordance with requirements contained in 10 CFR Part 40, Appendix A, including considerations of ALARA goals and the chemical toxicity of Uranium. On April 12, 1999, the U.S. NRC issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. The amendment to Criterion 6 (6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site reclamation plan or included in license applications. This report documents the modeling and assumptions made by Powertech (USA) to derive a standard for U-nat in soil for the proposed project ISL facility.

Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance (NRC, 2003) was published as Appendix E to the Standard Review Plan for *In Situ* Leach License Applications (NUREG-1569). This guidance discusses acceptable models and input parameters. This guidance from the RESRAD Users Manual (ANL, 2001), the Data Collection Handbook (ANL, 1993) and site-specific parameters were used in the modeling as discussed in the following sections.

6.4.1.1 Determination of Radium Benchmark Dose

RESRAD Version 6.4 computer code (RESRAD) was used to model the ISL site and calculate the maximum annual dose rate from the current radium cleanup standard.

The following supporting documentation for determination of the radium benchmark dose and the natural uranium soil standard (explained in Section 6.4.1.2) is attached in the Appendix 6.4-A (Radium Benchmark Dose Assessment, ERG, Inc., Oct., 2008):

- The RESRAD Data Input Basis (Attachment 1 of Appendix 6.4-A) provides a summary of the modeling performed with RESRAD and the values that were used for the input parameters. A sensitivity analysis was performed for parameters which are important to the major component dose pathways and for which no site specific data was available.

- Selected graphs produced with RESRAD that present the results of the sensitivity analysis performed on the input parameters are attached (Attachment 2 of Appendix 6.4-A).
- A full printout of the final RESRAD modeling results for the resident farmer scenario with the chosen input values is attached (Attachment 3.0 and 3.1 of Appendix 6.4-A). The printout provides the modeled maximum annual dose for calculated times for the 1,000-year time span and provides a breakdown of the fraction of dose due to each pathway.
- Graphs produced with RESRAD that present the modeling results for the maximum dose during the 1,000 year time span for radium-226 and natural uranium. A series of graphs depicting the summed dose for all pathways and the component pathways that contributes to the total dose are attached (Attachment 4.0 and 4.1 of Appendix 6.4-A).

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

6.4.1.2 Determination of Natural Uranium Soil Standard

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

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

Using a U-nat concentration in soil of 100 pCi/g, RESRAD determined a maximum dose of 7.1 mrem/yr. at time, t = 0 years. The printout of the RESRAD data summary is provided in

Attachment 3.1 of Appendix 6.4-A and the dose figures generated with RESRAD are provided in Attachment 4.1 of Appendix 6.4-A.

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

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

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

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

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

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

6.4.1.3 Uranium Chemical Toxicity Assessment

The chemical toxicity effects from uranium exposure are evaluated by assuming the same exposure scenario as that used for the radiation dose assessment. In the benchmark dose assessment for the resident farmer scenario, it was assumed that the diet consisted of 25 percent of the meat, fruits, and vegetables grown at the site. No intake of contaminated food through the aquatic or milk pathways was considered probable. Also, the model showed that the contamination would not affect the groundwater quality. Therefore, the same model will be used in assessing the chemical toxicity. The intake from eating meat was shown to be negligible compared to the plant pathway and therefore is not shown here. This is confirmed by the results of the RESRAD calculations shown in Attachment 3.1 of Appendix 6.4-A and the figures generated with RESRAD shown in Attachment 4.1 of Appendix 6.4-A.

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

5512 Vol. 1 (NRC, 1992). Table 6.4-1 provides the parameters used in these calculation and results for leafy vegetables, other vegetables, and fruit. Annual intakes of 14 kg/year and 97 kg/year were assumed for leafy vegetables and other vegetables and fruit, respectively. Consistent with Attachment 3.1 of Appendix 6.4-A dose calculations, it was assumed that 25 percent of the food was grown on the site. It was also assumed that the uranium concentration in the garden or orchard was 537 pCi/g. This corresponds to the uranium Benchmark Concentration for surface soils. Using a conversion factor for U-nat of 1 mg = 677 pCi, then 537 pCi/g is equivalent to 793 mg/kg. The human intake shown in the first column of Table 6.4-1 is equal to the product of the parameters given in the subsequent columns. Table 6.4-1 shows that the total annual uranium intake from all food sources from the site is 52.4 mg/yr.

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

Table 6.4-1: Annual Intake of Uranium from Ingestion

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

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

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

Where:

Q_P = uranium burden in the plasma, μg

IR = dietary consumption rate, mg U/d

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

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

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

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

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

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

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

The burden in kidney compartment 1 is:

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

Where:

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

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

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

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

Where:

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

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

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

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

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

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

IR = 0.14 mg/day

f_1 = 0.02

f_{ps} = 0.105

f_{pr} = 0.007

f_{pl} = 0.0105
f_{pt} = 0.347
f_{pk1} = 0.00035
f_{pk2} = 0.084
λ_{k1} = ln(2)/(5 yrs*365 days/yr)
λ_{k2} = ln(2)/7 days
where ln(2) = 0.693…

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

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

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

The ALARA principle requires an evaluation of, considering a cost benefit analysis and socio-economic impacts, the practicality of lowering established or derived soil cleanup levels. For

gamma-emitting radionuclides, the cost and potential impacts becomes excessively high as soil concentrations, thus the gamma emission rates, become indistinguishable from background.

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

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

6.4.2 Excavation Control Monitoring

The purpose of excavation control monitoring will be to guide the removal of contaminated material to the point where it is highly probable that an area meets the cleanup criteria.

Gamma surveys will be relied on to guide soil remediation efforts. At least 12 months prior to commencing reclamation, Powertech (USA) will submit a decommissioning plan that will contain descriptions of methodology for both pre- and post-reclamation gamma ray surveys. The gamma ray surveys for excavation control monitoring and final cleanup status will be designed to be consistent with NUREG-1569, Acceptance Criteria 6.4.3(1), 6.4.3(3) and 6.4.3(5), including the use of a methodology for gamma-ray surveys for excavation control monitoring and final status surveys that will provide 95% confidence that the survey units will meet the cleanup guidelines.

The post-operation (pre-decommissioning) radiological survey will consist of an integrated area gamma survey and confirmation soil sampling and analysis to verify that the required cleanup standard(s) are met. The areas that will receive particular attention are those that are expected to have higher readings than surrounding areas and include diversion ditches, surface impoundment areas, well fields (particularly those areas where spills or leaks may have occurred), process structures, storage areas, and on-site transportation routes for contaminated material and equipment. Areas associated with liquid waste disposal will also receive close attention. The surveys will identify soil contamination that exceeds the cleanup criteria and will be used to

guide the cleanup efforts. After cleanup, the surveys will be used, in conjunction with surface soil sample analyses, to verify cleanup to the site cleanup criteria.

Two methods are proposed for conducting site gamma surveys, the first is the use of the GPS-based radiological survey system and the second is the use of the equivalent conventional method using a Ludlum 2221 rate-meter/scaler and Model 44-10 detector.

Since the methods differ only by data recording and management, there will be no apparent differences in the accuracy of the results.

Gamma Action Level

A gamma action level, defined as a gamma count-rate level corresponding to the soil cleanup criterion, is used in the interpretation of the data. Normally the action level is conservatively developed to allow only a five percent error rate of exceeding the cleanup criteria at the

95 percent confidence level. The gamma action level may change as contaminated soil and associated gamma "shine" is removed. Thus, several action levels may be established. A particular action level will correspond to a gamma-ray count rate that conservatively predicts that the radium-226 in soil may be above the cleanup criterion. In addition, one action level will be required where radium-226 is the principal contaminant, such as in the well fields. Another action level will be required for areas affected by uranium releases, such as in plant areas.

The methods to determine gamma action levels will be determined prior to decommissioning.

For areas exhibiting contamination below the top 6 inches, excavation control monitoring will be done using the same detector deployed to determine the action level. Subsurface excavation control monitoring will consider the appropriate action level, adjusting for geometry factors.

After the remediation, the area will be resurveyed and the new data added to the database. Remediation will continue in areas not meeting action levels. This iterative procedure will be applied until all areas are determined to meet the action levels.

6.4.3 Surface Soil Cleanup Verification and Sampling Plans

Powertech (USA) will comply with the cleanup standard of Criterion 6(6) of 10 CFR Part 40, Appendix A: 11e.(2) byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, will not result in a TEDE exceeding the dose from cleanup of radium-contaminated soil to the above standard (benchmark dose), and will be at levels which are ALARA. If more than one residual radionuclide is present in the same 100 m^2 area, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed 1 (unity).

In areas that meet the Ra-226 cleanup criteria post-reclamation but that still have elevated Th-230 levels, Powertech (USA) will propose an acceptable protocol for Th-230 cleanup. Powertech (USA), in its final decommissioning plan, which will be submitted 12 months prior to any planned reclamation, will propose a concentration for Th-230 that, when combined with the residual concentration (residual thorium and products from thorium decay) that would be present in 1,000 years, meets the radium cleanup standard. In addition, Powertech (USA) will consider other potentially acceptable criteria before selecting and proposing a final cleanup criterion for Th-230 in the decommissioning plan.

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Compliance with cleanup criteria will be evaluated in terms of soil concentrations, which will be supplemented by field surveys employing gamma-ray measurements. A final gamma survey of the affected area and buffer zone will be performed using the GPS-based equipment or conventional equipment. Affected areas are those areas that have greater potential to be impacted by uranium solutions, dried uranium product (yellowcake) or liquid or solid waste streams that contain uranium or other radionuclides associated with uranium recovery operations. The areas that are most likely to be considered affected areas include diversion ditches, surface impoundment areas, well fields (particularly those areas where potential spills or leaks may have occurred), process structures, storage areas, on-site transportation routes for contaminated material and equipment, and areas associated with liquid waste disposal. Consistent with NUREG-1569, Acceptance Criterion 6.4.3(5), the survey method for verification of soil cleanup will be designed to provide 95% confidence that the survey units will meet the cleanup guidelines.

A calculation of the potential peak annual total effective dose equivalent (TEDE) within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site will be submitted to NRC for approval. Details will be provided in the decommissioning plan to be submitted for review at least 12 months prior to decommissioning activities. A key component of the plan will be that 11e.(2) byproduct material containing concentrations of radionuclides, other than radium in soil, and surface activity on remaining structures, must not result in a TEDE exceeding the dose from cleanup of radium contaminated soil to the radium benchmark dose, and must be at levels which are ALARA. Powertech (USA) is aware that the use of decommissioning plans with radium benchmark doses which exceed 100 mrem/yr, before application of ALARA, requires the approval of the Commission after consideration of the recommendation of the NRC staff.

6.4.4 Quality Assurance

After license issuance but prior to operations, Powertech (USA) will prepare a QAPP in accordance with Regulatory Guide 4.15 as described in Section 5.7.9. The QAPP will establish the quality assurance and control measures for field measurement, sample collection, and laboratory analysis for all decommissioning activities. The QAPP will also establish performance criteria for field and laboratory data precision, accuracy, completeness, and representativeness. The program will be designed to ensure that the project area is closed in a manner that permits release for unrestricted (i.e., any) use.

Powertech (USA) management will check all aspects of data collection and input to verify that procedures are being followed. The collection and handling of samples from the plant decommissioning, soil cleanup, and other radiological cleanup areas will be reviewed and approved by management. Laboratory results for these samples will be evaluated and validated to requirements in the QAPP. Other aspects of the reclamation including adherence to the SOPs and adherence to the decommissioning plan will be evaluated periodically by Powertech (USA) management. The construction process will be monitored to confirm that appropriate physical and radiological safety procedures are followed. Excavation processes will be monitored to ensure that contaminated materials are not handled carelessly and that any spillage is collected and contained. The conveyance of contaminated materials through the site, e.g., to stockpiling areas, will be monitored to prevent dispersal of these materials in the environment. Construction and sampling activities will be documented and reviewed throughout the reclamation process.

6.5 Decommissioning Health Physics and Radiation Safety

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels will be kept as low as reasonably achievable during decommissioning. The Radiation Safety Officer, Radiation Safety Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Section 5 will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of Regulatory Guide 8.30 or other applicable standards at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC. Records of all contaminated materials transported to a licensed disposal site will be maintained for five years, or as otherwise required by applicable regulations at the time of decommissioning.

6.6 Financial Assurance

In compliance 10 CFR Part 40 Appendix A criteria and NUREG-1569 and 1757, Powertech (USA) will maintain financial assurance instruments to cover the cost of reclamation including the costs of groundwater restoration, the cost of decommissioning, dismantling and disposal of all buildings and other facilities, and the reclamation and revegetation of affected areas for the

project.

Powertech (USA) commits to supplying a financial assurance mechanism in a form and in an amount approved by NRC staff in accordance with 10 CFR Part 40, Appendix A, Criterion 9 prior to the commencement of operations. Powertech (USA) is required to supply financial assurance cost estimates for NRC staff approval for construction and the first year of operations based on best available information, including contractor and material costs, using standard industry practices (Hydro Resources, Inc., 51 NRC 227, May 25, 2000). However, based on the Commission's decision, Powertech (USA) is not required to commit to a specific financial assurance instrument during the license application review process, nor is it required to supply the actual financial assurance instrument for the proposed cost estimates prior to the commencement of licensed activities.

Table 6.6-1 summarizes the financial assurance cost estimates for the Dewey-Burdock Project based on 2009 information. Detailed cost factors and tables are provided in Appendix 6.6-A. Pages 3 and 4 of Attachment RAP-2 of this appendix provide a summary of costs by year for the deep disposal well option and the land application option, respectively. The financial assurance model is based on the Dewey-Burdock Project being in operation for one full year prior to a third party taking over reclamation of the facility. Reclamation would include facility decommissioning, groundwater restoration, stability monitoring, well field reclamation, soil reclamation, and radiological surveys. The by-year costs are based on year 1 being the pre-operational construction phase, year 2 the full year of ISR operations, and year 3 the beginning of the financial assurance-funded reclamation activities. Groundwater restoration and stability monitoring would be conducted in years 3-4. Final decommissioning, including building demolition and soil reclamation, would be conducted during years 5-6.

Table 6.6-1: Summary of Financial Assurance Amounts

No.		Financial Assurance Estimate - Dewey-Burdock Project / Description	Table Referenced in App. 6.6-A (RAP-2)	Disposal Option: Disposal wells	Disposal Option: Land application
1		Facility Decommissioning			
	A	Salvageable equipment	9	$ 242,000	$ 242,000
	B	Non-salvageable building & equipment disposal	9,13	$ 710,080	$ 1,123,580
	C	11e.(2) byproduct material disposal	6	$ 466,609	$ 527,831
	D	Restore contaminated areas	9	$ 570,300	$ 1,429,100
2		O&M - Aquifer Restoration and Stability Monitoring			
	A	Method: RO treatment with permeate injection	O&M	$ 897,873	
	B	Method: Groundwater sweep with Madison injection	O&M		$ 555,700
3		Well Field Reclamation			
	A	Well plugging & closure	8, 14	$ 751,300	$ 751,300
	B	Remove surface equipment & reclaim	9	$ 975,050	$ 975,050
4		Radiological Survey and Environmental Monitoring	10	$ 10,300	$ 24,400
5		Project Management Costs & Miscellaneous	12	$ 968,700	$ 968,700
6		Labor, 35% overhead + 10% contactor profit	11	$ 1,337,000	$ 1,337,000
7		Contingency @ 15%		$ 1,039,382	$ 1,190,199
Total Financial Assurance Amount				$ 7,968,594	$ 9,124,861

The financial assurance cost estimate reflects costs as of 2009. The cost factors found in Appendix 6.6-A, Attachment RAP-2, Table 2 and elsewhere were obtained from vendor quotes, from the 2009 RS Means cost estimating handbooks, from recent ISR license applications, and from calculations as described. All electrical power costs are conservatively based on a per kWh hour cost of $0.07; the results of a power study (Lyntek, 2010) showed estimated 2013 power costs of $0.0595 to $0.0691 per kWh, depending on the supplier. The costs of 11e.(2) byproduct material disposal, as listed in Appendix 6.6-A, Attachment RAP-2, Table 2 and as utilized in Table 6, are based on the assumption that Powertech (USA) will secure a byproduct disposal contract with Denison Mines Corporation for disposal at their byproduct disposal facility at White Mesa, UT. The cost estimate is based on a transportation distance of 785 miles from the project area to the White Mesa facility near Blanding, UT. Transportation costs to alternate 11e.(2) byproduct material disposal facilities will be similar or less. For example, the Pathfinder

Mines Corporation Shirley Basin Facility is approximately 250 miles away, the Energy Solutions LLC Clive Disposal Site near Clive, UT is approximately 700 miles away, and the Waste Control Specialists LLC facility near Andrews, TX is approximately 900 miles away.

Powertech (USA) proposes use of a flare factor of 1.44 and the restoration estimate of 6 pore volumes of groundwater for its financial assurance. Basis for the flare factor is found in Appendix 6.6-B, "Numerical Modeling of Groundwater Conditions Related to In Situ Recovery at the Dewey-Burdock Uranium Project, South Dakota." Refer to Section 6.1.6 for justification of the flare factor and total number of restoration pore volumes. As explained in more detail in Section 6.1.6, the flare factor is based on experience gained from ISR operations in Wyoming and on numerical groundwater modeling. The number of PVs necessary for restoration is also based on experience from other ISR operations after allowing for improvements in technology, including reduced groundwater sweep, which was found to be ineffective at some other operations, and elimination of long delays, sometimes up to several years, which proved to be less effective than completing restoration soon after uranium recovery was completed.

While it is likely that the facility buildings will have a salvage value, the demolition cost estimate assumes that all buildings will be shredded and disposed at an appropriate landfill. Decommissioning costs include a final gamma survey.

Labor costs associated with the reclamation operations will be a combination of contract labor and direct hires, listed in Appendix 6.6-A, Attachment RAP-2, Table 11. A full-time Radiation Safety Officer will be employed through final decommissioning.

All of the financial assurance information contained in the license application as well as the information in Table 6.6-1 has been consolidated into a restoration action plan (RAP), which is provided as Appendix 6.6-A.

Powertech (USA) will revise these financial assurance cost estimates after license issuance based on NRC approval of the methodologies for cost estimate calculations. In the event that additional factors are utilized for adding or subtracting from NRC-approved cost estimates, Powertech (USA) will provide a written explanation of such factors when submitting revised cost estimates after license issuance.

Powertech (USA) commits to providing annual financial assurance updates to NRC staff, including any revisions to financial assurance cost estimates based on a series of factors including, but not limited to: (1) inflation; (2) changes in contractor costs; (3) changes in material

costs; and (4) changes in restoration elements such as pore volumes. Pursuant to NUREG-1757, Volume 3, Powertech (USA) also commits to (i) automatically extend the financial assurance instrument for the previously approved financial assurance amount until NRC approves the revised financial assurance cost estimates if NRC staff has not approved its proposed revisions thirty (30) days prior to the expiration date of the existing financial assurance instrument; (ii) revise the financial assurance instrument within ninety (90) days of NRC approval of any revised decommissioning plan if the revised cost estimate exceeds the amount of existing financial assurance costs; (iii) submit for NRC staff review an updated financial assurance package to cover any planned expansion or operational change not included in the previous annual financial assurance update at least ninety (90) days prior to beginning such associated construction; and (iv) provide NRC staff with copies of financial assurance-related information submitted to the State of South Dakota and/or EPA, including a copy of the financial assurance review or final financial assurance package.

6.7 References

ANL, 1993, "*Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil*", Environmental Assessment Division, Argonne National Laboratory, ANL/EAIS-8, Argonne, Illinois.

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".

ERG, Inc., 2008, "*Radium Benchmark Dose Assessment for Dewey-Burdock Uranium In-situ Recovery Facility*", Environmental Restoration Group, Inc., Albuquerque, NM.

ICRP, 1995, ICRP Publication 69 – "*Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 3 Ingestion Dose Coefficients*", International Commission on Radiation Protection, Tarrytown, New York.

Lyntek, 2010, Updated Power Study Report, Dewey Burdock Project, Custer & Fall River County, South Dakota, unpublished report prepared for Powertech (USA) Inc. by Lyntek, February 25, 2010.

NRC (1983), "*Aquifer Restoration at In-Situ Leach Uranium Mines: Evidence for Natural Restoration Processes*", NUREG/CR-3136, Washington DC: USNRC. April 1983.

NRC, 1992, "*Residual Radioactive Contamination from Decommissioning*," U.S. Nuclear Regulatory Commission, NUREG/CRR-5512 (PNL-7994) Vol. 1, Washington, DC.

NRC, 2003, "*Standard Review Plan for In situ Leach Uranium Extraction License Applications*", Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material Safety and Safeguards, U. S. Nuclear Regulatory Commission, NUREG-1569, Washington, DC.

NRCS, 2007, "*2003 Annual National Resources Inventory*", Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, DC.

TVA, 1979, "*Draft Environmental Statement – Edgemont Uranium Mine*", Tennessee Valley Authority, Knoxville, Tennessee.

USGS, 2004, "*Estimated Use of Water in the United States in 2000*", U.S. Geological Survey, U.S. Department of the Interior, USGS Circular 1268, Reston, Virginia.

7.0 Potential Environmental Effects

This section discusses potential direct and indirect environmental impacts (effects) that may be temporary (short term) or permanent (long term) in nature, and are associated with the construction and operation of the Dewey-Burdock Project. After a complete site specific analysis of the potential impacts of the Proposed Action Powertech (USA) concludes that such potential impacts fall within the scope of the analysis and conclusions in NUREG-1910 regarding the South Dakota-Nebraska Region.

7.1 Potential Environmental Effects of the Site Preparation and Construction

Site preparation and construction activities associated with the project facilities include site characterization, drilling wells, clearing and grading related to building and road construction, installation of pipelines, and construction of evaporation ponds. Construction at an ISL site is phased and iterative as new well fields are developed throughout the life of the project.

7.1.1 Potential Air Quality Effects of Construction

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

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

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

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

7.1.2 Potential Land Use Effects of Construction

Rangeland and pastureland are the primary land uses within the PAA and the surrounding 2 km review area. While, the Proposed Action site encompasses 10,580 acres, the land potentially disturbed by the Proposed Action will be approximately 68 acres (facilities, piping, ponds, well fields and roads) the year proceeding operation. The disturbed area during the life of the project (production to restoration) is estimated to increase over time to a maximum of 108 acres. If the maximum area for land application of treated wastewater is included in the footprint of the Proposed Action, then approximately a maximum additional 355 acres would be affected by the Proposed Action for most of the project life. The maximum potential disturbance at any given time is expected to be 463 acres.

Under the proposed action, this land will be temporarily converted from its previous use as rangeland and pastureland to ISL use on a “phased” basis. The land will likely experience an increase in human activity also contributing to further land disturbance. The disturbance associated with drilling and pipeline and facility construction will be limited and temporary as vegetation will be re-established through concurrent reclamation. The construction of new access and secondary roads will be minimized to the extent possible.

Recreational use within the project boundary is limited primarily to large game hunting. Within the PAA, hunting is currently open to the public on approximately 5,700 acres. Approximately 240 acres are owned by the Bureau of Land Management (BLM); the South Dakota Game Fish and Parks (SDGF&P) lease around 3,000 acres annually of privately owned land and currently designate this acreage as walk-in hunting areas. Prior to commencement of operations Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable.

Additional potential land use impacts could include the disruption to livestock grazing within the PAA. This disturbance will be temporary in the area until the area is released for unrestricted use. Potential impacts include surface soil contamination from leaks or spills in well fields or

from pipelines, but site reclamation will ensure that such impacts are temporary and eliminated prior to site closure.

7.1.3 Potential Surface Water Effects from Construction

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

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

There were 20 potential wetland sites evaluated by the USACE; the determination rendered 4 of the 20 evaluated as Jurisdictional sites (see Appendix 7.1-A). Descriptions of the jurisdictional determination: Ephemeral Tributary to Beaver Creek, Ephemeral Tributary to Pass Creek, Pass Creek (NonRPW), Beaver Creek (Perennial RPW). Beaver Creek is the only perennial stream within the PAA and the rest of the natural water flow is ephemeral. Of the jurisdictional determinations within the PAA, potential impact is expected to be small and none are expected to experience direct impact from the pre-operational or operational activities. Erosion potential is present due to the possible construction of the wells near the drainage area; however, disturbance is expected to be mild and short-term.

An old mine pit located at Waypoint 37 was determined to be a non-wetland area. Although surface water was present, there was no hydrophytic vegetation or hydric soils. This old mine pit is also located along a disturbance area. The concentration of old mine pits along the eastern edge of the permit area contained small PUB wetlands (0.175 acres) that are a product of the old mine pits, that could be directly impacted by the disturbance areas located along the old mine pits.

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

7.1.3.1 Potential Surface Water Effects from Sedimentation

Increased sedimentation of water bodies due to construction activities may be a concern at the site. Land clearing for construction of roads, well pads, pipelines, and other various structures may result in soil exposure to water and wind erosion. Soil is often compacted by vehicle use during various construction activities, resulting in decreased soil permeability, and thus increased water runoff. The soil exposure and increased water runoff may cause sedimentation to be carried into surface water bodies.

7.1.4 Potential Population, Social, and Economic Effects of Construction

The construction phase of the project could result in moderate impacts to the local economy as a result of purchasing goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs are expected to be minor or non-existent and temporary in duration.

For the construction phase of the project, an estimated 86 payroll workers will be engaged directly in construction activities. An estimated 176 additional non-payroll positions will be created in Custer and Fall River Counties as a result of construction activities and non-payroll capital expenditures incurred by the project.

7.1.5 Potential Noise Effects of Construction

Because of the remote location of the project site and lack of sensitive receptors, noise impacts are not expected to increase beyond ambient levels due to plant operations. Likewise, no detrimental off-site noise impacts are anticipated due to the increase in commuter and truck traffic volumes or from construction. Noise levels generated during operation of the ISL project

are not expected to result in any significant impacts to violate any noise standards. Open rangeland and pastureland are the primary land uses within the PAA and the surrounding 2 km area.

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

7.2 Potential Environmental Effects of Operations

This section describes the environmental effects of operation at the ISL project. Operations activities include:

- Ongoing well field construction activities including well drilling and construction, construction of access roads, installation of pipelines and utilities, and headerhouse construction
- CPP and well field production operations
- Groundwater restoration activities associated with well field decommissioning
- Final site reclamation activities

Potential environmental concerns from the operation of the project are addressed in the following sections and include: air quality impacts, land use impacts, geological and soil impacts, impacts to cultural resources, water quality impacts, and ecological impacts.

7.2.1 Potential Air Quality Effects of Operations

The project site is not expected to be a major point source emitter and is not expected to be classified as a major source of emissions. New emissions are introduced during the operation phase of an ISL project including the release of pressurized vapor from well field pipelines. Other additional possible emissions include those that may be emitted during resin transfer or elution. Naturally occurring radon gas may also be released when the well pipeline system is vented. This is the greatest air quality concern of ISL operations. Radon gas release is discussed further in Section 4.1.1. Non-radiological emissions from pipeline system venting, resin transfer, and elution are expected to have a minimal impact on air quality at the site due to the low volume of effluent produced and the rapid dispersion of the emissions.

Yellowcake drying operations can also produce gaseous effluents, with the greatest concern being the release of uranium particles. As discussed in Section 3.2.5, the yellowcake will be dried at approximately 250°F in a rotary vacuum drying process. The off gases generated during the drying cycle are filtered through a baghouse, which is located on the top of the dryer, to remove particles down to approximately 1 micron in size. The gases are then cooled and scrubbed in a surface condenser to further remove the smaller size fraction particulates and the water vapor during the drying process. The potential impacts related to yellowcake drying are expected to be small due to the required filtration systems put in place.

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

7.2.2 Potential Land Use Effects of Operations

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

The Proposed Action could temporarily impact recreational use, limited primarily to large game hunting, within the project boundary. Within the PAA, hunting is currently open to the public on approximately 5,700 acres (2,302 ha). Approximately 240 acres (97.12) are owned by the Bureau of Land Management (BLM); the South Dakota Game Fish and Parks (SDGF&P) lease around 3,000 acres (1,241 ha) annually of privately owned land and currently designate this acreage as walk-in hunting areas. Prior to commencement of operations Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable.

Additional potential land use impacts could include the disruption to livestock grazing within the PAA. Approximately 9.46 acres (3.828 ha) will be removed from grazing on the BLM land. This disturbance will be temporary in the area until the area is released for unrestricted use. Potential impacts include surface soil contamination from leaks or spills in well fields or from pipelines, but site reclamation will ensure that such impacts are temporary and small prior to site closure. Given the relatively small size of the area impacted by operations, the exclusion of grazing from this area over the course of the project is expected to have minimal impact on local livestock production.

7.2.3 Potential Geologic and Soil Effects of Operations

The following section discusses the potential geological and soil impacts of operations at the project.

7.2.3.1 Potential Geologic Effects of Operations

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

Impacts are more likely to occur from other geologic factors such as earthquakes. As discussed in Section 2.6.7, the maximum magnitude earthquake estimated for the PAA is a VII on the Modified Mercalli Scale, corresponding to a Richter magnitude of 6.1.

Due to the design of the project, no significant geologic impacts are anticipated, according to NUREG-1910.

7.2.3.2 Potential Soil Effects of Operations

There are two main drainage basins located in the PAA; each of the drainages have different soil types. The soil mapping unit descriptions are in Section 2.6.6. The Beaver Creek basin is composed of Haverson loam, and has 0-2 percent slopes throughout the drainage. The Cottonwood Gallery basin is composed of Barnum silt loam in the south half of the drainage and Barnum-Winetti complex, and has 0-6 percent slopes. The old mine pits were also classified as Barnum silt loam and Barnum-Winetti complex.

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

- Compaction
- Loss of productivity
- Loss of soil
- Salinity

- Soil contamination

These impacts could potentially occur via:

- Clearing vegetation
- Compaction
- Excavation
- Leveling
- Redistribution of soil
- Stockpiling

Severity of impacts to soil is dependent upon type of disturbance, duration of disturbance and quantity of acres disturbed. Construction and operation activities have the potential to compact soils. Soils most sensitive to compaction, clay loams, are not present within the Proposed Permit Area, however; due to the use of heavy machinery and high volume within certain area some soils have the potential for compaction. Compaction of the soil can lead to decreased infiltration thereby increasing runoff. Soils compacted during construction and operations will be restored (i.e., disced and reseeded) as soon as possible following use.

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

During land application disposal, there could be potential impacts to the soil from elevated TDS and electrical conductivity (EC) values in the water (Table 4.2-6) to be used to irrigate crops and salt tolerant wheat grasses. Irrigation water quality is commonly assessed in terms of soluble salt content, percentage of sodium, boron, and bicarbonate contents. In the case of the water used for irrigation the soluble salts are on the order of 3,000 to 4,000 µS/cm at 25 ^{o}C. These levels pose low to moderate risk to the growth of moderately sensitive crops such as alfalfa and corn. The SAR levels are low and pose little risk to water erosion during the infiltration of rain or snowmelt. There could be some salt deposition at the surface, however maintaining maximum

crop growth will reduce the possibility of undesirable species. During the irrigation season, water application rates will be determined to optimize both evaporation and crop production.

Table 7.2-1: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Production Ground Water Quality([a])

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

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

1. ESP = Exchangeable Sodium Percentage. Empirical relationship from Withers and Vipond (1980). $ESP = \frac{100(-0.0126 + 0.01475 * SAR)}{1 + (-0.0126 + 0.01475 * SAR)}$
2. RSC = Residual Sodium Carbonate (meq/L). $RSC = ([CO_3] + [HCO_3]) - ([Ca] + [Mg])$
3. SAR = Sodium Adsorption Ratio. $SAR = \frac{[Na]}{\sqrt{([Ca] + [Mg])/2}}$

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

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

7.2.3.2.1 Monitoring Well Rings, Well Field and Associated Piping

The scale of monitoring well rings will have little impact on the amount of soil disturbance. Differences in disturbance to soil will depend on area of monitoring well ring and natural growth of vegetation within the specific well field. During construction of each well field, drilling activities will occur only on a small percentage of an ISL site at any one time (HRI, 1997a). The amount of land disturbed at any time typically will range from 100 to 400 acres (EPA 2007); however, some ISL sites may be larger or smaller. Disturbance associated with drilling and pipeline and facility installation normally will be limited, as the affected area can be reclaimed and reseeded in the same season. Vegetation normally will be re-established over these areas within 2 years (NMA, 2007).

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

Movement of drilling and construction equipment and installation of wellheads, piping systems, and other facilities will disturb small areas of surface soil. Vehicle movement could cause

compaction, rutting, and other disturbances to the surface soil and rocks. Depending on the intensity and duration of construction activities, compaction and erosion of surface soil could alter drainage and cause accelerated erosion and degradation of surrounding surface water resources. However, good management practices likely will minimize, if not eliminate, any such potential impacts (NMA, 2007).

7.2.3.2.2 Wastewater Retention Ponds

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

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

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

7.2.3.2.3 Deep Disposal Wells

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

destined for deep-injection well disposal will require compliance with EPA UIC regulations and, as such, the potential impacts will be negligible (NMA, 2007).

7.2.3.2.4 Well Fields

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

7.2.4 Potential Archeological Resources Effects of Operations

As discussed in Section 2.4.1, a Level III Cultural Resources Evaluation was conducted in the PAA. Personnel from the Archaeology Laboratory, Augustana College (Augustana), Sioux Falls, South Dakota, conducted on-the-ground field investigations between April 17 and August 3, 2007.

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

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

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

As construction of ISL facilities takes place any previously undetected historical or cultural resources will be reported to the proper agency. The site will be evaluated and released by the proper agency before construction continues within the specific area. The phased approach that Powertech (USA) proposes will increase the likelihood of safeguarding historical and/or cultural resources. Another example of phasing, with which Powertech (USA) agrees, is a license condition that requires cessation of any site activities and the conduct of a cultural resources inventory if previously undetected historic or cultural properties are discovered during the development and construction of wellfields. Thus, “phasing” is an essential and integral component of *all aspects* of ISL uranium recovery projects (NMA, 2007).

7.2.4.1 Potential Visual and Scenic Resources Effects

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

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

The project could result in temporary, minor impacts to visual and scenic resources. The project will maintain the visual resource classification of the area. According to NUREG-1569, if the visual resource evaluation rating is 19 or less, no further evaluation is required. Based on the visual resource inventory conducted in June 2008, the total score of the two Scenic Quality

Rating Units within the Proposed License Area were 11 and 13; therefore, no further evaluation of the existing scenic resources or future changes to the scenic resources of the area due to the proposed project will be required.

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

7.2.5 Potential Groundwater Effects on Operations

Consumption of groundwater and short-and long-term changes to groundwater are some of the potential groundwater impacts related to the operation of an ISL uranium operation.

7.2.5.1 Potential Drawdown

Based on numerical modeling developed from site-specific parameters and calibrated to historical pumping test data (Appendix 6.1-A), the estimated maximum drawdown outside of the project area resulting from projected ISR operations is approximately 12 feet in the Fall River aquifer and 10 feet in the Chilson aquifer. These simulations were for net extraction rates resulting from a gross production pumping rate of 8,000 gpm (or twice the maximum proposed pumping rate), a 1 percent production bleed rate, and the use of groundwater sweep during aquifer restoration. Since Powertech (USA) has committed to removing domestic wells within the project area from private using (refer to Section 5.7.1.3.2), these represent the maximum anticipated drawdown amounts for nearby domestic wells.

If Powertech (USA) were to use a bleed rate of 3 percent during the operations phase, drawdowns in the nearest domestic wells in the Fall River and Chilson aquifers may be greater than those estimated for a 1 percent bleed rate; however, as noted above, the maximum simulated drawdown was performed for a gross production pumping rate of twice that proposed and for the optional groundwater sweep during aquifer restoration. Therefore, it represents a conservatively high estimate of the potential drawdown resulting from operations and restoration.

Based on the numerical modeling in Appendix 6.1-A, water levels will recover to near pre-operational levels within 1 year after groundwater withdrawals cease.

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7.2.5.1.1 Monitoring

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

7.2.5.2 Potential Effects on Ore Zone Groundwater Quality

A potential environmental impact to groundwater as a result of ISL is the degradation of water quality in the ore zone within the well field areas. The impact, in and of itself, it is of limited, due to the fact that the groundwater quality is very poor prior to uranium ISL operations; this is due to the presence naturally occurring radionuclide levels that exceed EPA and/or state drinking water limits which serve as the base criteria for an UIC aquifer exemption and which can never serve as a USDW (HRI, 1997; NMA, 2007).

Powertech (USA) has proposed to use gaseous oxygen and carbon dioxide lixiviant. The interaction of the lixiviant with the mineral and chemical constituents of the aquifer results in an increase in trace elements and salinity during recovery due to a decrease in pH and IX. There is no conveyance of new constituent species from the recovery process into the groundwater. The recovery process may however raise levels of specific constituents that are present within the ore bearing zone and host aquifer pre-operations.

The reduced, insoluble form of uranium present in the ore zone pre-operations is solubilized as a direct result of oxidation via the ISL process when oxidized uranium is introduced to bicarbonate anions and become mobile for extraction. This is the most noticeable impact to the groundwater as a direct result of the ISL process. Although other trace constituents are mobilized during the ISL process, the concentrations of these constituents are dependent upon the specific mineralogy of each deposit and oxidation of trace elements for example: (1) iron sulfides would result in higher concentrations of sulfate; (2) ferroelite would result in higher selenium concentrations

(NMA, 2007). If these minerals are present in the respective ore zone it would result in a change in the pH from alkaline range down to a range in the neutral scale, thus causing calcium carbonate to dissolve and result in another pH change moving upward to a more alkaline range due to the increase in calcium, chloride and carbonate.

During the IX above ground process, the uranium on the resin beads is exchanged for chloride. This chloride is introduced into the barren solution in the form of sodium chloride; therefore via the oxidation process which encourages pH adjustment and the IX process, the groundwater concentrations of constituents such as: calcium, sodium, carbonate, bicarbonate, sulfate, chloride, TDS, uranium, and pH are usually increased until the groundwater restoration is initiated within each well field (NMA, 2007).

7.2.5.3 Potential Groundwater Quality Effects from Excursions

Excursions have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized during the ISL process. There are two types of excursions: vertical and horizontal. A vertical excursion is movement of solution into overlying or underlying aquifers. A horizontal excursion is a lateral movement of leach fluids outside the production zone of the orebody aquifer.

Vertical excursions can be caused by vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers. These head gradients can be caused by potential increases in pumping from either the underlying or overlying aquifers for water supply in the vicinity of the ISL facility. Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could also lead to vertical movement of solutions and excursions.

Another potential source of vertical excursions is potential well integrity failures during ISL operations. Inadequate construction, degradation, or accidental rupture of well casings above or below the uranium-bearing aquifer could allow lixiviant to travel from the well bore into the surrounding aquifer. Deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create pathways for vertical excursions as well.

During normal ISL operations, inward hydraulic gradients are maintained by production bleed such that groundwater flow is towards the production zone from the edges of the well field. This inward gradient helps minimize the chance of a horizontal excursion occurring. The potential impact of a horizontal excursion could be significant should a large volume of contaminated

water leave the production zone and move downgradient within the production aquifer to a zone used for water production. To reduce the likelihood and minimize the consequences of potential horizontal excursions, a ring of monitoring wells will be installed within and encircling the production zone to enable early detection of excursions. If an excursion is detected corrective actions will be taken and the well will be placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

7.2.5.4 Potential Groundwater Effects from Spills

Types of spills that could potentially impact groundwater during operations include: a leak in a storage pond, a release of pregnant and/or barren leach fluid, a release of injection or production solutions from associated piping, spills and potential well rupture. Potential impacts of contamination to shallow aquifers and surrounding soils may result from one or a combination of these types of spills. The likelihood of spills is minimized by way of rigorous safety training, and employing all necessary preventative procedures such as maintaining injection pressures below casing and formation rupture pressures, monitoring pressure in the header houses with instrumentation equipped with alarms and interlocks for early warning and maintaining operating pressures so as to minimize the likelihood for potential impacts to shallow aquifers. Refer to Section 3.2.12 for additional information.

7.2.5.5 Potential Groundwater Effects from Land Application

Land application of treated wastewater could potentially cause radiological or other constituents, such as Selenium or other metals, to accumulate in soils or infiltrate into shallow aquifers. NRC and state release limits for land application of treated wastewater are expected to mitigate the potential effects of land application of treated wastewater on shallow aquifers.

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

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

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

7.2.6 Potential Surface Water Effects

Construction activities within the well fields, along the pipeline courses and roads, and at the process plant have the potential to increase the sediment yield of the disturbed areas. However, due to the relatively small size of these disturbances compared to the overall area and to the size of the watersheds, the increase is expected to be minimal. A slight increase in sediment yields and total runoff can be expected during final reclamation, however well field decommissioning and reclamation activities throughout the life of the project will help to reduce this increase.

In areas where surface structures including well fields and associated structures, access roads, office buildings, pipelines, facilities and other structures associated with ISL production and processing could affect surface water drainage patterns, diversion ditches and culverts will be used to minimize erosion and control runoff.

7.2.6.1 Potential Surface Waters and Wetlands

Powertech (USA) plans to construct several well fields atop the multiple disturbance areas located throughout the permit area. Process facilities are planned to be located adjacent to the uranium rollfront areas.

In the northwest section of the PAA the ore bodies lie to the northeast of Beaver Creek, the wetlands along Beaver Creek will not be directly impacted by the disturbance areas. Erosion potential is present due to the construction of the wells near the drainage; however, disturbance is short-term.

An old mine pit located at Waypoint 37 was determined to be a non-wetland area. Although surface water was present, there was no hydrophytic vegetation or hydric soils. This old mine pit is also located along a disturbance area. The concentration of old mine pits along the eastern edge of the permit area contained small PUB wetlands (0.175 acres) that are a product of the old mine pits. The wetlands associated with old mine pits are not planned to be disturbed.

The remaining disturbance areas in the PAA are located near a few small wetlands. These wetlands are likely not to have direct impacts from the wellfields presence but there may be indirect impacts due to the construction of the well fields.

Construction, operation, or reclamation activities, which cause disturbance or impacts to jurisdictional wetlands on the proposed Dewey-Burdock Project, will be performed in accordance with appropriate Nationwide Permits, if applicable. Nationwide Permit (NWP) 44 non-coal mining activities, which requires Pre-construction Notification (PCN) for all activities, NWP 12 utility line activities, which requires a PCN for an area where a section 10 permit is required, discharges that result in the loss of >1/10 acre, and NWP 14 linear transportation projects, which requires a PCN for 1/2 acre in non-tidal waters. NWP 44 has an acreage limit of half an acre for Waters of the United States (WoUS), NWP 12 and 14 also has a half an acre disturbance limit. Impacts to Other Waters of the United States (OWUS) are not considered under the acreage limit. (Federal Register V. 72, No. 47/ Monday, March 12, 2007 Notices) The wetlands found along Beaver Creek are recommended to be jurisdictional since Beaver Creek connects to the Cheyenne River which is a significant nexus. All other wetlands presented in this study are recommended to be non-jurisdictional since the wetlands are all isolated and do not support interstate commerce.

7.2.6.1.1 Wetland Survey Conclusions

The majority of the wetlands in the PAA fall within Beaver Creek, the remaining wetlands are dispersed throughout the PAA as small depressions and ponds, old mine pits, and an old open flowing well. The wetlands within the old mine pits are not planned to be disturbed and these areas are likely to be excluded from the disturbance areas. The remaining wetlands in the PAA

are likely not to suffer a direct impact due to the construction of the well fields. There may be some minimal indirect effects to a few of the small depressional wetlands.

The PAA had 14.199 acres of wetland channel, 2.338 acres of isolated PEM, PEMC, PABJh, and PUSA ponds; 5.248 acres of PUB isolated depressions, 2.706 acres of PUS isolated depressions, and 10.623 acres of old mine pits classified as PUB, PEM, or OW. Wetlands found along Beaver Creek totaled 13.376 acres of wetland channel. These wetlands found along Beaver Creek are recommended to be jurisdictional because Beaver Creek connects to a significant nexus, the Cheyenne River. The remaining wetlands are recommended to be non-jurisdictional as they are isolated and do not connect to a jurisdictional source.

Final determination of jurisdictional decision lies within the U.S. Army Corp of Engineers.

Powertech (USA) plans to construct several well fields and a CPP for the project. Where wetlands intersect the orebody, it has been assumed that impacts could occur from the presence of well fields. No wetland will be impacted due to the construction of the CPP. In the northwest section of the PAA, the ore bodies lie to the northeast of Beaver Creek; therefore, the wetlands along Beaver Creek will not be directly impacted by the well fields. The remaining disturbance areas in the PAA are located near a few small wetlands. These wetlands are not likely to have direct impacts from the presence of the well fields, but there may be indirect impacts due to the construction of the well fields. As noted in Section 2.8, the wetlands located within the PAA are recommended as non-jurisdictional except for the wetlands located along Beaver Creek that are recommended to be jurisdictional. In the event that construction, operation, or reclamation activities cause disturbance or potential impacts to jurisdictional wetlands on the proposed project, appropriate Nationwide Permits will be followed, if applicable.

Drainages or surface waters within the PAA will not be significantly impacted during construction or operations. In the northwest section of the of the PAA near Beaver Creek, erosion potential is present due to the construction of the wells near the drainage; however, this disturbance will be short-term and disturbed areas will be reclaimed concurrently as the well field progresses.

7.2.6.2 Potential Surface Water Effects from Sedimentation

The disturbance associated with normal construction activities, and heavy use of roads and activities associated with the wellfields, pipeline and CPP, have the potential to increase sediment yields. The potential impacts from increased sedimentation will be minimal because of

the short-term nature of the disturbance (areas will be concurrently reclaimed) and the area of disturbance is small compared to the total drainage basin of Angostura Reservoir (total area 7143 square miles). Beaver Creek is the only perennial stream within the PAA and the rest of the natural water flow is ephemeral. Preventative sedimentation measures will be taken for disturbances that have the potential to increase sediment yields; therefore, potential impacts to surface water will be limited to uncommon precipitation or runoff events.

The modification of the land surface that is associated with ISL operations including well fields, a CPP, offices, roads and other structures should have a negligible impact on the peak surface water flow because the relatively planar topography of the PAA, low annual precipitation, and the comparatively small area of disturbance within the much larger Angostura Reservoir Basin.

7.2.6.3 Potential Surface Water Effects from Accidents

Potential impacts from accidents to surface water include the uncontrolled release of process materials into the environment or a release or spill from the operation or well field (e.g., handling of fuels, lubricant, oily wastes, chemical wastes, sanitary wastes, herbicides, and pesticides).

7.2.7 Potential Ecological Effects of Operations

The following section discusses the ecological potential impacts of operations at the project site.

7.2.7.1 Vegetation

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

Construction activities and increased soil disturbance could stimulate the introduction and spread of undesirable and invasive, non-native species within the PAA. Non-native species invasion and establishment has become and increasingly important result of previous and current

disturbance in South Dakota. No threatened or endangered vegetation species were observed within the PAA; therefore, no impacts are anticipated.

7.2.7.2 Wildlife and Fisheries

ISL uranium production varies from typical open pit mining by using less intrusive extraction methods that are more efficient and, thus, have less impact on the surrounding area. In situ operations use a series of injection and production wells that extract the uranium from the orebody without physically removing the ore or overburden from the ground.

Despite the relatively limited surface disturbance associated with ISL uranium production, operations can have direct and indirect impacts on local wildlife populations. These impacts are both short-term (until successful reclamation is achieved) and long-term (persisting beyond successful completion of reclamation). However, the latter category is not expected to be substantial due to the relatively limited habitat disturbance associated with this industry. The direct impacts of ISL production on wildlife include: injuries and mortalities caused by collisions with project-related traffic or habitat removal actions such as topsoil stripping, particularly for smaller species with limited mobility such as some rodents and herptiles; and restrictions on wildlife movement due to construction of fences. The likelihood for the impacts resulting in injury or mortality is greatest during the construction phase due to increased levels of traffic and physical disturbance during that period. Overall traffic will increase from current levels and will persist during production, but should occur at a reduced, and possibly more predictable level than during the construction phase. Speed limits will be enforced during all construction and maintenance operations to reduce impacts to wildlife throughout the year, but particularly during the breeding season.

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

Multiple site visits and targeted surveys conducted over the last year, combined with existing agency databases that encompass the PAA and input from local residents, indicate that the PAA and surrounding vicinity is occupied by a wide variety of common wildlife and fish species, with only a few species of particular concern occurring in the area. The most notable species of interest is the bald eagle, which is still considered threatened at the state level. Bald eagle winter roost sites and a successful nest site were documented within the PAA during surveys conducted in 2007 and 2008. Two other species tracked by the SDNHP were confirmed or suspected to have nested in the PAA in 2008, the long-eared owl and long-billed curlew, respectively. Eight additional SDNHP species were documented in or near the PAA during baseline surveys. However, those observations consisted of birds flying over the area, or sightings made in the surrounding perimeter. No grouse leks have been recorded within 6 miles of the PAA during agency or project-specific surveys completed in recent years.

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

Some vegetative communities currently present in the PAA can be difficult to reestablish through artificial plantings, and natural seeding of those species would likely take many years. However, the current habitat of greatest concern (Big Sagebrush Shrublands) occurs only in scattered stands that are relatively small and widely-spread across the License area. Results from lek searches, breeding bird surveys, and small mammal trapping, as well as regular site visits in all seasons over the last year, strongly suggest that sage obligates other than pronghorn occur in limited numbers in the PAA, if at all. The vegetative communities (Cottonwood Gallery and Ponderosa Pine) that indicated the strongest associations between terrestrial species and habitats

during baseline surveys will not be physically impacted by construction or operation of the proposed project. It is possible that the potential implementation of center-pivot irrigation using treated wastewater may enhance nesting, brood-rearing, and/or foraging habitat for some species. Consequently, although individual animals associated with some specific habitats could be impacted by the proposed ISL operations, the small percentage of projected surface disturbance within the PAA relative to its overall size, and the low density of nesting efforts relative to habitat presence in that area, suggest that their populations as a whole will experience minimal insignificant impacts from the project. Advanced planning of construction siting and activities in concert with continued monitoring can further reduce impacts and assist with the development of mitigation options, if necessary. Potential impacts to these species and others are discussed in greater detail in the following sections.

7.2.7.3 Big Game

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

7.2.7.4 Other Mammals

Medium-sized mammals (such as lagomorphs, canids, and badgers) may be temporarily displaced to other habitats during the initial ISL production activities. Direct losses of some small mammal species (e.g., voles, ground squirrels, mice) may be higher than for other wildlife due to their more limited mobility and likelihood that they would retreat into burrows when disturbed, and thus be potentially impacted by topsoil scraping or staging activities. However, given the limited area expected to be disturbed by the project, such impacts would not be

expected to result in major changes or reductions in mammalian populations for small or medium-sized animals. "Displaced species may re-colonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and suitable habitats are reestablished" (NUREG-1910, 2000). Few bats were recorded in the area despite extra efforts to observe them during the baseline surveys. Those that were seen were near water bodies near treed habitats which are not currently scheduled for disturbance. The mammalian species known to be, or potentially, present in the PAA have shown an ability to adapt to human disturbance in varying degrees, as evidenced by their continued presence in other mining and residential areas of similar, or greater, disturbance levels elsewhere in the region. Additionally, small mammal species in the area have a high reproductive potential and tend to re-occupy and adapt to altered and/or reclaimed areas quickly.

7.2.7.5 Raptors

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

Eight intact raptor nests were documented within the project survey area (PAA and 2.0 km perimeter) during 2008; the mid-July 2007 start date for this project precluded nesting data from being collected last year. Six of the eight nest sites are within the PAA, with the remaining two located in the one-mile perimeter. USFWS guidelines recommend a non-disturbance buffer of 0.25 to 1.0 mile around active raptor nests for species known to nest, or suspected of nesting, in the PAA (USFWS, 1998). Buffer recommendations are lowest for the two owl species in the area, as they are typically more tolerant of human activities near active nest sites. The bald eagle has the greatest buffer distance around active nests, while a 0.5-mile buffer is recommended for red-tailed hawks and merlins. Nests of most other raptor species, including all others observed,

but not documented nesting, in the proposed action area are typically buffered by a radius of 0.25 to 0.50 mile.

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

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

7.2.7.6 Upland Game Birds

ISL production in the PAA would potentially impact the foraging and nesting habitat of mourning doves, though such disturbance is not expected to have any marked impacts on this species. No woody corridors will be disturbed by the proposed activities, and additional trees are present in the cottonwood gallery along the Cheyenne River, located approximately 2 miles south of the PAA, where production is not projected to occur in the near future. Additionally, doves are not restricted to treed habitats, nor are they subject to any special mitigation measures for habitat loss.

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

7.2.7.7 Other Birds

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

7.2.7.8 Waterfowl and Shorebirds

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

7.2.7.9 Reptiles and Amphibians

As with waterfowl, potential habitat for aquatic and semi-aquatic amphibians and reptiles, is limited within the PAA and occurs primarily along Beaver Creek in the western portion of the area. Other water bodies are ephemeral, and thus offer only short-term habitat. Activities associated with the project are not expected to disturb existing surface water or alter the topography in the area. Those species residing in rocky outcrops located in potential disturbance

areas could be impacted by construction and maintenance operations. However, few non-aquatic herptile species were observed in the PAA and surrounding perimeter. Any impacts that would occur would affect individuals, but would not likely impact the population as a whole.

7.2.7.10 Fish and Macro-Invertebrates

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

Due to the arid climate and proposed location of new project facilities, operation of the well fields is not expected to alter aquatic habitat or water quality in perennial streams. No surface water will be diverted for use in the operation, and no process water will be discharged into aquatic habitat.

Pass creek provides only seasonal drainage and does not support fish or significant amphibian habitat. Some of the proposed land application sites west of the SF would be located in close proximity to Beaver Creek, the primary aquatic habitat in the project vicinity. Beaver Creek would not be directly affected by the well field operations or land application sites.

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

7.2.7.11.1 Federally Listed Species

As described in the preceding sections of this document, no federally listed vertebrate species were documented in the project survey area (current PAA and 2 km perimeter) during the year-long survey period, or during previous targeted surveys conducted for the original claims (TVA 1979). Additionally, the USFWS has issued a block clearance for black-footed ferrets in all black-tailed prairie dog colonies in South Dakota except northern Custer County, and in the entire neighboring state of Wyoming. That clearance indicates that ferrets do not currently, and are not expected to, occupy the PAA. Only one small black-tailed prairie dog colony was present in the PAA itself during the 2007-2008 baseline surveys, and local landowners are actively working to remove the animals from their lands. Consequently, the proposed project will have no direct, indirect, or cumulative effects on black-footed ferrets.

7.2.7.11.2 State Listed Species

ISL production within the project may affect, but is not likely to adversely affect bald eagles, the only state listed species known to inhabit the PAA. Bald eagles were documented at winter roosts and an active nest within the PAA for this project. However, most roost sites and the lone nest site are at least 1.0 mile from the nearest planned facility associated with this project. Additionally, no more than 2 or 3 bald eagles were observed during any given winter survey despite the numerous available (and unoccupied) mature trees along Beaver Creek, Pass Creek, and the pine breaks located in and near the PAA. Three proposed land application sites (center pivot irrigation systems) would currently fall within the one-mile buffer of the bald eagle nest. However, those systems are typically automated, and the minimal disturbance associated with potential maintenance of those systems should not be significant enough to impact nesting or roosting bald eagles along Beaver Creek.

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

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

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

right-of-way corridors to consolidate new infrastructure will reduce these potential indirect impacts.

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

7.2.7.11.3 Species Tracked by SDNHP

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

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

7.2.8 Potential Noise Effects of Operations

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

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

7.2.9 Potential Cumulative Effects of Other Uranium Development Projects

The National Environmental Policy Act (NEPA) defines cumulative effects as "...impacts [that] can result from individually minor but collectively significant actions taking place over a period of time." The PAA is within the Nebraska – South Dakota – Wyoming Uranium Milling Region, which has a history of conventional uranium surface mining. According to the NRC GEIS there were no identified coal mines within this uranium milling region that might affect the cumulative impacts of the project or other uranium developments.

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

Powertech (USA) is currently investigating several prospective uranium ISL projects along with other companies within the Nebraska – South Dakota – Wyoming Uranium Milling Region. These projects are in various stages of development. At the time of this application Powertech (USA) is not aware of other licensing or permitting applications that have been submitted for any of these projects, therefore; Powertech (USA) can not accurately predict the cumulative impacts that potential projects that might have, should they be developed.

7.3 Potential Radiological Effects

This section includes an assessment of the radiological effects of the site, types of emissions the potential pathways present, and an evaluation of potential consequences of radiological emissions.

The site will consist of two facilities. One facility will be the CPP, located near Burdock. The other facility will be the SF, located near Dewey.

Since the site may dispose of treated process water via land application, emission of natural uranium, lead-210 (Pb-210), radium-226 (Ra-226), and thorium-230 (Th-230) is expected. The release estimates for natural uranium, Pb-210, Ra-226, and Th-230 are calculated using methods found in “MILDOS-AREA: An Update with Incorporation of In Situ Leach Uranium Recovery Technology” by Faillace et al. and DOE Handbook “Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities” by the US Department of Energy.

Due to the presence of Ra-226 in the soil from land application of wastewater, the land application areas will emit radon-222 (Rn-222), a decay product of Ra-226. The estimated release of Rn-222 is calculated using the previously mentioned methods as well as the methods found in Regulatory Guide 3.64, “Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers” (RG 3.64) by the US Nuclear Regulatory Commission. The details of and assumptions used in these calculations are found in Section 7.3.3.2.1.

Since the drying and packaging operation, to be conducted at the CPP, will be under vacuum, the only expected routine emission at the facilities and well fields will be Rn-222 gas. Radon-222 is dissolved in the lixiviant as it travels through the ore to a production well where it is brought to the surface. The concentration of Rn-222 in the production solution and estimated releases are calculated using the methods found in Regulatory Guide 3.59, “Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations” (RG 3.59) by the Nuclear Regulatory Commission. The details of and assumptions used in these calculations are found in Sections 7.3.3.2.2 through 7.3.3.2.5.

MILDOS-AREA is used to model potential radiological impacts on human and environmental receptors (e.g. air and soil) using site-specific radionuclide release estimates, meteorological and population data, and other parameters. The estimated radiological impacts resulting from routine site activities will be compared to applicable public dose limits as well as naturally occurring background levels.

7.3.1 Potential Exposure Pathways

Figure 7.3-1 presents potential exposure pathways from all potential sources in the site. The predominant pathways for planned and unplanned releases are identified. As mentioned earlier, atmospheric Rn-222 is expected to be the predominant pathway for impacts on human and environmental media. Impacts of Rn-222 releases can be expected in all quadrants surrounding the site, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, Rn-222 itself has very little radiological impact on human health or the environment. Radon-222 has a relatively short half-life (3.2 days) and its decay products are short lived, alpha emitting, nongaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. As Figure 7.3-1 shows, all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radionuclides are evaluated by MILDOS-AREA.

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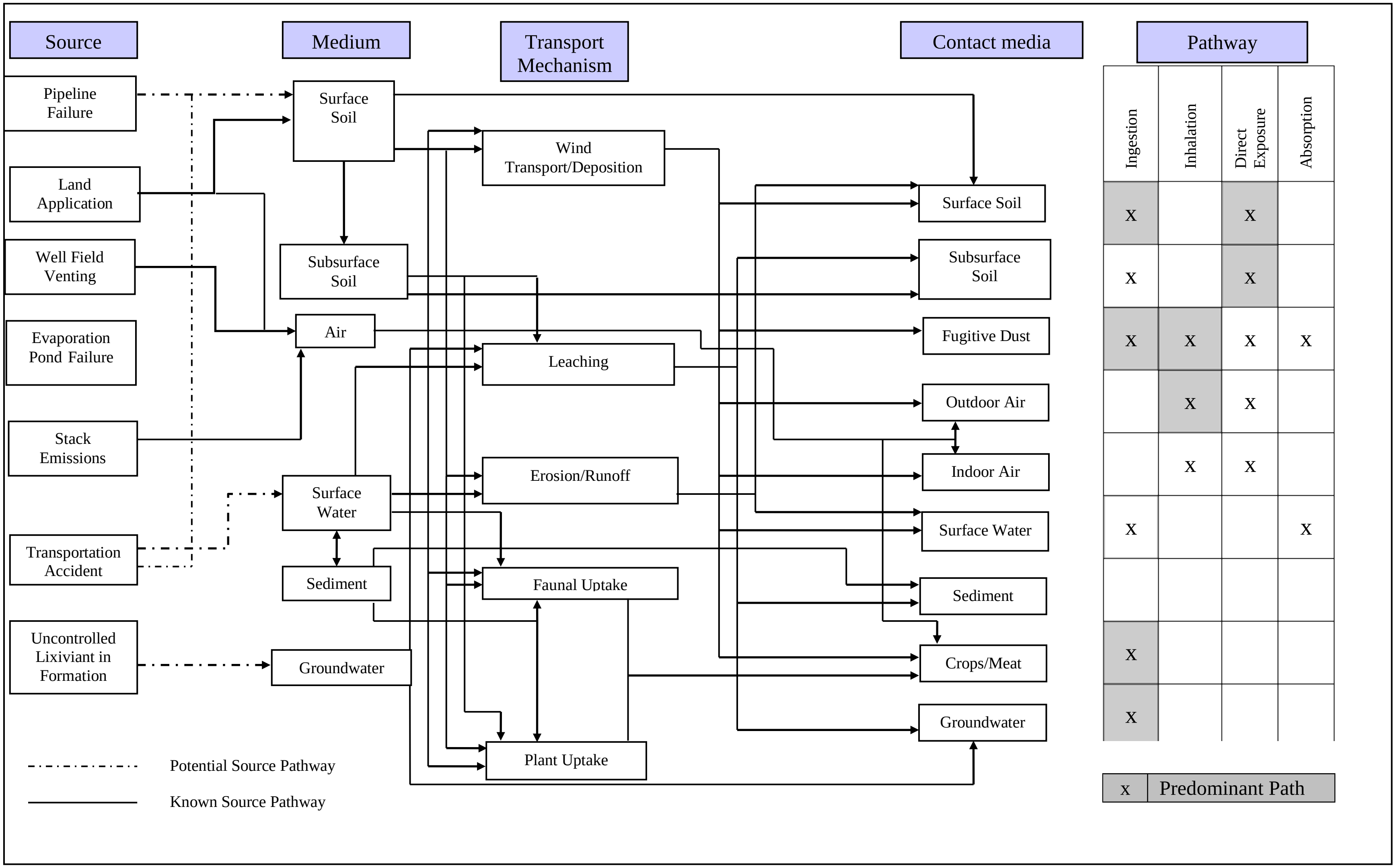

Figure 7.3-1: Human Exposure Pathways

7.3.2 Exposures from Water Pathways

The leach fluids in the ore zone will be controlled and monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

Two methods of waste disposal at the facility are being considered: Either treatment to remove radium and subsequent injection in a Class V disposal well, or by treatment followed by land application. Emission estimates from the land application processes are described in Sections 7.3.3.1 and 7.3.3.2.

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

7.3.3 Exposures from Air Pathways

Sources of radionuclide emissions are Pb-210, natural uranium, Ra-226, and Th-230 released into the atmosphere from the land application areas. The land application areas are also a source of Rn-222, as are the well fields and the resin transfers at the SF. The total effective dose equivalent (TEDE) to nearby residents in the region and at the facility boundaries was estimated using MILDOS-AREA. The parameters used to estimate releases are provided in Table 7.3-1.

Table 7.3-1: Parameters Used to Estimate Radionuclide Releases from the Project Site

Parameter	Value	Unit	Variable Name	Source
Rate of land application - 1	1.27E-03	$m\ d^{-1}$	AR_1	Application
Rate of land application - 2	2.79E-3	$m\ d^{-1}$	AR_2	Application
Area of land application - Dewey	1.27E+06	m^2	LA_{Dewey}	Application
Area of land application - Burdock	1.27E+06	m^2	$LA_{Burdock}$	Application
Time of land application in a year - 1	80	d	t_{d1}	Application
Time of land application in a year - 2	137	d	t_{d2}	Application
Years of land application	15	y	t_y	Application
Concentration of natural uranium in water	300	$pCi\ L^{-1}$	$[U\text{-}nat]_{water}$	Application (NRC effluent values)
Concentration of thorium-230 in water	100	$pCi\ L^{-1}$	$[Th\text{-}230]_{water}$	Application (NRC effluent values)
Concentration of radium-226 in water	60	$pCi\ L^{-1}$	$[Ra\text{-}226]_{water}$	Application (NRC effluent values)
Concentration of lead-210 in water	10	$pCi\ L^{-1}$	$[Pb\text{-}210]_{water}$	Application (NRC effluent values)
Density of soil - Dewey	1.28	$g\ cm^{-3}$	ρ_{Dewey}	Application
Density of soil - Burdock	1.24	$g\ cm^{-3}$	$\rho_{Burdock}$	Application
Depth of contamination	0.15	m	x	Assumption
Distribution coefficient of natural uranium in loam soil	15	$cm^3\ g^{-1}$	$K_{d,U\text{-}nat}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of thorium-230 in loam soil	3300	$cm^3\ g^{-1}$	$K_{d,Th\text{-}230}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of radium-226 in loam soil	36000	$cm^3\ g^{-1}$	$K_{d,Ra\text{-}226}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of lead-210 in loam soil	16000	$cm^3\ g^{-1}$	$K_{d,Pb\text{-}210}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Soil volume water content - Dewey	0.91	unitless	w_{Dewey}	Application
Soil volume water content - Burdock	0.80	unitless	$w_{Burdock}$	Application
Rate of resuspension of radionuclides in surface soil	4E-06	h^{-1}	ARR	DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy

Table 7.3-1: Parameters Used to Estimate Radionuclide Releases from the Project Site (Cont'd)

Parameter	Value	Unit	Variable Name	Source
Respirable fraction of resuspended radionuclides in surface soil	1.0	unitless	RF	DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy
Soil porosity - Dewey	0.5429	unitless	n_{Dewey}	Application
Soil porosity - Burdock	0.5340	unitless	$n_{Burdock}$	Application
Lixiviant flow rate - production	1.49E+04	L min^{-1}	$M_{production}$	Application
Lixiviant flow rate - restoration	3.73E+03	L min^{-1}	$M_{restoration}$	Application
Lixiviant residence time	108	d	t	Application
Production days per year	360	d	D	Application
Formation porosity	0.34	unitless	n_{form}	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al. (coefficient for sandstone)
Content of radium in ore	592	pCi g^{-1}	$[Ra]_{ore}$	Application
Formation density	1.9	g cm^{-3}	ρ_{form}	Application
Storage time in mud pits	7	d	T	Application
Number of mud pits per year	725	y^{-1}	N	Application
Resin porosity	0.38	unitless	n_{resin}	Application
Resin transfers per day	0.5	d^{-1}	N_i	Application
Volume of resin per transfer	1.42E+04	L	V_i	Application
Average mass of ore material in mud pit	185	g	m	Application
Radon emanation coefficient	0.22	unitless	E	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.

7.3.3.1 Source Term Estimates – Natural Uranium, Pb-210, Ra-226, Th-230

The source terms used to estimate natural uranium, Pb-210, Ra-226, and Th-230 releases from the land application areas are calculated. The parameters used to estimate releases are provided in Table 7.3-1. In cases where site-specific information was not available, conservative values based on published information were used.

For purposes of modeling in MILDOS-AREA, the land application areas are consolidated into clusters. All the land application areas in Dewey are grouped into one cluster called “Dewey”. The land application areas in Burdock are grouped into one cluster called “Burdock.” The locations of the sources representing the clusters are the centroids of the clusters.

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

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

Where:

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

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

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

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

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

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

Where:

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

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

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

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

Where:

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

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

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

Where:

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

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

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

Where:

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

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

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

Where:

R_d = Retardation factor

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

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

Where:

K_d = Distribution coefficient ($cm^3\ g^{-1}$)

w = Soil volume water content

Using the parameters in Table 7.3-1 and Equations 7.1-7, the release rates are calculated for natural uranium (U-Nat), thorium-230 (Th-230), radium-226 (Ra-226), and lead (Pb-210) and shown in Table 7.3-2.

Table 7.3-2: Estimated Soil Concentrations ($pCi\ g^{-1}$) and Release Rates ($Ci\ y^{-1}$) from the Project Site

Location	X (km)	Y (km)	U-Nat		Th-230		Ra-226		Pb-210	
			Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate
Land Application - Dewey	-6.02	3.80	10.8	0.0974	3.78	0.0325	2.27	0.0195	0.378	0.00325
Land Application - Burdock	-1.09	0.99	11.2	0.0974	3.91	0.0325	2.34	0.0195	0.391	0.00325

7.3.3.2 Source Term Estimates – Rn-222

Sources of radon releases are the land application areas, the well fields, the CPP, and resin transfers in the SF. The well fields consist of production well fields, restoration well fields, and

new well fields. In order to be conservative, the well field in Dewey closest upwind to a receptor (Well Field 5) was modeled in MILDOS-AREA. Likewise, the well field in Burdock closest upwind to a receptor (Well Field 2) was modeled in MILDOS-AREA.

7.3.3.2.1 Land Application Releases

In addition to natural uranium, Ra-226, Pb-210, and Th-230; the land application areas are also sources of Rn-222. The radon source term is calculated using Equation 7.8 and the parameters listed in Table 7.3-1:

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

Where:

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

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

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

Where:

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

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

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

Where:

n	=	Porosity

Using the parameters listed in Table 7.3-1 and Equations 7.8 through 7.10, the release rates of Rn-222 from land application are calculated. The Rn-222 release rates are 6.08 Ci y^{-1} for Dewey and 7.49 Ci y^{-1} for Burdock.

7.3.3.2.2 Production Releases

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

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

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

Where:

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

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

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

Where:

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

Using Equations 7.11, 7.12 and the parameters listed in Table 7.3-1, the yearly radon released to production fluid is 2117 Ci y^{-1}. RG 3.59 assumes all the Rn-222 that is released to the production fluid is ultimately released to the atmosphere which in the case of IX columns operating at atmospheric pressure in an open system is an appropriate conservative assumption. In cases where pressurized downflow IX columns are used, and well fields are operated under pressure, the majority of radon released to the production fluid stays in solution and is not released. The radon which is released is from occasional well field venting for sampling events, small unavoidable leaks in well field and IX equipment, and maintenance of well field and ion

exchange equipment. For this reason, estimated annual releases of 10 percent of the Rn-222 in the production fluid would occur in the well fields and an additional 10 percent in the IX circuit was assumed. Given these assumptions, the annual Rn-222 released from production in the well field and at the CPP is 212 and 191 Ci y^{-1}, respectively. Since the SF is planned to operate at the same parameters as the CPP, the annual Rn-222 released from production in the well field and at the SF is also 212 and 191 Ci y^{-1}, respectively. This 10 percent release rate also includes Rn-222 released from the 1-5 percent bleed from the production well field that may be treated or disposed of. Three percent of the Rn-222 released at the CPP and SF was attributable to deep well disposal at each facility.

7.3.3.2.3 Restoration Releases

Radon-222 releases resulting from well field restoration activities were estimated in the same manner as the production activities above (i.e. using Equations 7.11 and 7.12) but modified for the lower restoration flow rate listed in Table 7.3-1. The assumption of a 10 percent release in the well field and the CPP results in releases of 26.5 and 23.8 Ci y^{-1}, respectively. Since the SF is planned to operate at the same parameters as the CPP, the annual Rn-222 released from restoration in the well field and at the SF is also 26.5 and 23.8 Ci y^{-1}, respectively. Three percent of the Rn-222 released at the CPP and Satellite Facility was attributable to deep well disposal at each facility based on estimated restoration bleed rates.

7.3.3.2.4 New Well Field Releases

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

The yearly Rn-222 released from new well field development is calculated using Equation 7.13:

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

Where:

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

Using Equation 7.13 and the parameters listed in Table 7.3-1, the yearly radon released from new well field development is 3.6E-05 Ci yr^{-1}.

7.3.3.2.5 Resin Transfer Releases

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

The yearly radon released from resin transfers is calculated using Equation 7.14:

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

Where:

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

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

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

Where:

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

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

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

Where:

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

Using Equations 7.13 through 7.16 and the parameters listed in Table 7.3-1, the yearly radon released from resin transfers at the SF is 0.523 Ci y^{-1}. This assumes the ore grade mined at the SF would yield the same radon concentration in production fluid as at the CPP.

7.3.3.2.6 Radon-222 Release Summary

A summary of estimated radon-222 releases from the site is presented in Table 7.3-3. The source coordinates in Table 7.3-3 are relative to the CPP.

Table 7.3-3: Estimated Releases (Ci y^{-1}) of Radon-222 from the Project Site

Location	X (km)	Y (km)	Production	Restoration	Drilling	Resin Transfer	Land Application	Total
Production Well Field (5)	-3.86	3.48	212	26.5	3.6E-05	0	0	238.5
Production Well Field (2)	1.83	-0.56	212	26.5	3.6E-05	0	0	238.5
SF	-5.00	3.54	134	16.7	0	0.523	0	151.2*
SF Deep Well	-5.00	3.54	57	7.1	0	0	0	64.1*
Total SF			191	23.8		0.523		215.3
CPP	0	0	134	16.7	0	0	0	150.7*
CPP Deep Well	0	0	57	7.1	0	0	0	64.1*
Total CPP			191	23.8	0	0	0	214.8
Land Application - Dewey	-6.02	3.80	0	0	0	0	6.08	6.08
Land Application - Burdock	-1.09	0.99	0	0	0	0	7.49	7.49
Total			806	100.6	7.2E-05	0.523	14.0	921

* These estimated releases are included in the total SF and CPP estimated releases and are not added again in the Total of 921 Ci/y.

7.3.3.3 Receptors

The receptors used in the MILDOS-AREA simulations are presented in Table 7.3-4 and include the property boundary in 16 compass directions of the CPP and SF, 7 residences, and the town of Edgemont. The coordinates and distance values contained in Table 7.3-4 are in relation to the CPP.

Table 7.3-4: Project Receptor Names and Locations

Location	X (km)	Y (km)	Distance (km)
Boundary - CPP - N	0.00	2.82	2.82
Boundary - CPP - NNE	1.07	2.78	2.96
Boundary - CPP - NE	1.16	1.17	1.65
Boundary - CPP - ENE	2.64	1.01	2.83
Boundary - CPP - E	2.60	0.00	2.60
Boundary - CPP - ESE	2.53	-0.97	2.71
Boundary - CPP - SE	2.13	-2.14	3.02
Boundary - CPP - SSE	0.85	-2.25	2.41
Boundary - CPP - S	0.00	-2.87	2.87
Boundary - CPP - SSW	-1.09	-2.84	3.04
Boundary - CPP - SW	-2.44	-2.43	3.44
Boundary - CPP - WSW	-2.37	-0.90	2.54
Boundary - CPP - W	-2.32	0.00	2.32
Boundary - CPP - WNW	-2.29	0.87	2.45
Boundary - CPP - NW	-2.55	2.52	2.45
Boundary - CPP - NNW	-1.42	3.70	3.96
Boundary - SF - N	-4.92	5.28	7.22
Boundary - SF - NNE	-4.23	5.25	6.74
Boundary - SF - NE	-2.70	5.64	6.25
Boundary - SF - ENE	-3.35	4.01	5.23
Boundary - SF - E	-2.97	3.43	4.54
Boundary - SF - ESE	-3.00	2.69	4.03
Boundary - SF - SE	-2.81	1.30	3.10
Boundary - SF - SSE	-3.55	-0.15	3.55
Boundary - SF - S	-4.91	-0.25	4.92
Boundary - SF - SSW	-5.70	1.38	5.86
Boundary - SF - SW	-6.28	2.06	6.61
Boundary - SF - WSW	-6.24	2.92	6.89
Boundary - SF - W	-7.02	3.43	7.81
Boundary - SF - WNW	-6.98	4.21	8.15
Boundary - SF - NW	-6.24	4.69	7.81
Boundary - SF - NNW	-5.40	4.67	7.14
Resident - Daniels Ranch	2.13	0.02	2.13
Resident - Spencer Ranch	-2.00	1.21	2.34
Resident - BC Ranch	-6.64	3.81	7.66
Resident - Puttman Ranch	-5.16	7.23	8.88
Resident - Burdock School	-2.25	-1.96	2.98
Resident - Heck Ranch	1.73	-6.38	6.61
Resident - Andersen Ranch	-5.3	-3.0	6.0
Town - Edgemont	11.03	-18.59	21.62

7.3.3.4 Miscellaneous Parameters

The metrological data used in the MILDOS-AREA model is from the joint frequency distribution data presented in Section 2.5.2 of this application.

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

7.3.3.5 Total Effective Dose Equivalent (TEDE) to Individual Receptors

In order to show compliance with the annual dose limit found in 10 CFR part 20.1301, Powertech (USA) has demonstrated by calculation that the total TEDE to the individual most likely to receive the highest dose from the project uranium in situ recovery operation is less than 100 mrem y^{-1}. Additionally, the annual effective dose equivalent (EDE) limit found in 40 CFR part 190 of 25 mrem y^{-1} was not exceeded at any receptors. The results of the MILDOS-AREA simulation for each receptor in Table 7.3-4 are presented in Table 7.3-5. The output from the MILDOS-AREA simulation for the land application option is in Appendix 7.3-A. The output for the MILDOS-AREA simulation for the deep disposal well option is in Appendix 7.3-B.

An evaluation of the TEDE calculations follows:

- The maximum 40 CFR part 190 EDE of 6.69 mrem y^{-1}, located at an arbitrary receptor on the license boundary NNW of the SF, is 26.8 percent of the public dose limit of 25 mrem y^{-1}. There is no actual receptor at this location so someone would have to reside here for a full year to receive this estimated dose. The 40 CFR 109 TEDE public dose limit is not exceeded at any boundary receptor. If the land application sources were excluded from the MILDOS-AREA model, no doses would exceed the 40 CFR part 190 dose limits since these limits specifically exclude sources of radon-222.

- The maximum total TEDE of 7.88 mrem y^{-1}, located at an arbitrary receptor on the license boundary NNW of the SF, is 7.88 percent of the 10 CFR 20 public dose limit of 100 mrem y^{-1}. The 10 CFR 20 public dose limit is not exceeded at any receptor. If the land application sources were excluded from the MILDOS_AREA model, the TEDE at this location would be 1.12 mrem y^{-1}.

- The maximum 40 CFR part 190 EDE at a potential residence is 3.06 mrem y^{-1}, located at the Spencer Ranch. This is 12.2 percent of the public dose limit of 25 mrem y^{-1}. None of these estimated EDEs exceed the 10 CFR 20 constraint rule for airborne effluents of 10 mrem y^{-1}. If the land application sources were excluded from the MILDOS-AREA model, no doses would exceed the 40 CFR part 190 dose limits, since those limits specifically exclude sources of Rn-222.

- The maximum TEDE at a potential residence is 4.49 mrem y^{-1}, located at the Spencer Ranch. This is 4.49 percent of the 10 CFR 20 public dose limit of 100 mrem y^{-1}. If the land application sources were excluded from the MILDOS-AREA model, the TEDE at this location would be 1.37 mrem y^{-1}.

Table 7.3-5: Estimated Total Effective Dose Equivalent (TEDE) and Effective Dose Equivalent (EDE) to Receptors Near the Project Site

Receptor	Distance from Main Plant (km)	40 CFR part 190 EDE* (mrem y^{-1})	TEDE* (mrem y^{-1})
Boundary - CPP - N	2.82	0.90	1.65
Boundary - CPP - NNE	2.96	0.58	1.23
Boundary - CPP - NE	1.65	1.43	2.48
Boundary - CPP - ENE	2.83	0.73	1.47
Boundary - CPP - E	2.60	0.96	2.10
Boundary - CPP - ESE	2.71	0.94	3.02
Boundary - CPP - SE	3.02	0.92	3.05
Boundary - CPP - SSE	2.41	0.97	2.99
Boundary - CPP - S	2.87	0.63	2.08
Boundary - CPP - SSW	3.04	0.60	1.77
Boundary - CPP - SW	3.44	0.52	1.43
Boundary - CPP - WSW	2.54	0.78	1.94
Boundary - CPP - W	2.32	1.37	2.72
Boundary - CPP - WNW	2.45	2.25	3.65
Boundary - CPP - NW	2.45	1.60	3.17
Boundary - CPP - NNW	3.96	0.88	1.61
Boundary - SF - N	7.22	0.84	1.71
Boundary - SF - NNE	6.74	0.65	1.51
Boundary - SF - NE	6.25	0.51	1.05
Boundary - SF - ENE	5.23	1.12	2.43
Boundary - SF - E	4.54	1.28	2.77
Boundary - SF - ESE	4.03	1.48	3.53
Boundary - SF - SE	3.10	2.03	3.70
Boundary - SF - SSE	3.55	1.08	2.36
Boundary - SF - S	4.92	0.66	1.70
Boundary - SF - SSW	5.86	0.99	2.37
Boundary - SF - SW	6.61	0.95	2.05
Boundary - SF - WSW	6.89	1.47	2.62
Boundary - SF - W	7.81	1.17	2.00
Boundary - SF - WNW	8.15	1.32	2.00
Boundary - SF - NW	7.81	2.16	2.93
Boundary - SF - NNW	7.14	6.69	7.88
Resident - Daniels Ranch	2.13	1.23	2.51
Resident - Spencer Ranch	2.34	3.06	4.49
Resident - BC Ranch	7.66	1.34	2.27
Resident - Puttman Ranch	8.88	0.41	0.85
Resident - Burdock School	2.98	0.62	1.64
Resident - Heck Ranch	6.61	0.30	1.04
Resident - Andersen Ranch	6.0	0.26	0.88
Town - Edgemont	21.61	0.10	0.30

* All doses reported in this table are infant dose. Dose estimates at the same location for children, teenagers and adults are lower than infant estimates.

7.3.3.6 Population Dose

The annual population dose commitment to the population in the region within 80 km of the project site is also predicted by the MILDOS-AREA code. The results are contained in Table 7.3-6 where TEDE is expressed in terms of person-rems. For comparison, the dose to the population within 80 km of the facility due to background radiation has been included in the table. Background radiation doses are based on a North American population of 346 million and an average TEDE of 360 mrem.

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper, Wyoming, during the year 1978. The results of these calculations are included in Table 7.3-6. These calculations are also combined with the dose to the region within 80 km (50 mi) of the facility to arrive at the total radiological effects of one year of operation at the project site.

The maximum radiological effect of the project operation would be to increase the TEDE of continental population by 0.000007 percent.

Table 7.3-6: Total Effective Dose Equivalent to the Population from One Year's Operation at the Project Site

Criteria	TEDE (person rem/yr)
Dose received by population within 80 km of the facility	0.241
Dose received by population beyond 80 km of the facility	8.10
Total continental dose	8.35
Background North American dose	1.2E8
Fractional increase to background dose	7.0E-8

7.3.3.7 Exposure to Flora and Fauna

MILDOS-AREA estimates surface deposition rates of Ra-226 and its decay products as a function of distance from the source and calculates surface concentrations. Table 7.3-7 presents the highest surface concentrations of Ra-226 and its decay products predicted by MILDOS-AREA over a 100-year period. Soil concentrations were calculated based on a conservative assumption of 1.5 g cm^{-3} bulk soil density.

Table 7.3-7: Highest Surface Concentrations of Radium-226 and its Decay Products Resulting from Project Operations

Radionuclide	Distance from site (km)	Direction	Surface concentration ($pCi\ m^{-2}$)	Soil concentration in upper 15cm ($pCi\ g^{-1}$)
Radium-226	1.5	WNW	60	2.7 E-4
Polonium-218	1.5	WNW	75	3.3 E-4
Lead-214	1.5	WNW	75	3.3 E-4
Bismuth-214	1.5	WNW	75	3.3 E-4
Lead-210	15.0	S	1.4	6.2 E-6

The largest increase in soil concentration is 2.7 E-4 pCi g^{-1} of radium-226. Recent site specific surface soil (0-15 cm) data show that the background concentration of radium-226 ranges from 0.76 (25 percentile) to 2.2 (75 percentile) pCi g^{-1} with a geometric mean of 1.3 pCi g^{-1} and geometric standard deviation of 1.3 pCi g^{-1}. The increase in soil radioactivity is less than the geometric mean soil radioactivity prior to uranium recovery operations and if added to the geometric mean (1.3 pCi g^{-1}) is still within normal background variability observed at the site. Assuming the most important pathways to flora and fauna exposure start with radionuclide concentrations in soil, the impacts from normal site operations would be minimal and probably not distinguishable from background.

7.3.3.8 Determination of Land Application Effects

7.3.3.8.1 Potential Radiological Effects

RESRAD Version 6.4 computer code (RESRAD) was used to model the site and calculate the maximum annual dose rate from the land application processes for a resident farmer scenario.

The soil concentration parameters used in the model were the soil concentrations calculated for the Dewey cluster in Section 7.3.3.1. The soil concentrations for Burdock were chosen because they are they are the most conservative (higher than) when compared to Dewey. The soil concentrations are 11.2 pCi g^{-1} for U-nat, 3.91 pCi g^{-1} for Th-230, 2.34 pCi g^{-1} for Ra-226, and 0.391 pCi g^{-1} for Pb-210. However, U-nat is composed of three isotopes of uranium: uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238).

The activity composition of U-nat is 49.2 percent U-234, 2.2 percent U-235, and 48.6 percent U-238. Therefore the 11.2 pCi g^{-1} of U-nat is composed of 5.51 pCi g^{-1} U-234, 0.246 pCi g^{-1} U-235, and 5.44 pCi g^{-1} U-238. These concentrations were used in the model.

The area of contamination used in the model was the area of the Dewey cluster, 450 acres. The distribution coefficients that were selected for each radionuclide were RESRAD default values. All other input parameters were the same as those used in the Ra-226 benchmark modeling described in Attachment 1 of Appendix 6.4-A and in Section 6.4.

The maximum annual dose rate from the land application areas, including radon, is 63.2 mrem y^{-1} at t = 0 years. Not including radon, the dose rate is 14.4 mrem y^{-1}. The major exposure pathways are radon, external, and plant (water independent). A full printout of the final RESRAD modeling results is in Appendix 7.3-D. This shows that the radiological impacts of the land application process are minimal and meet the license termination for unrestricted use criteria in 10CFR 20.1402 of 25 mrem per year to a critical group.

7.3.3.8.2 Potential Non-radiological Effects

Steady-state, non-radioactive metals concentrations in the land application area surface soils were determined using Equations 7.4 through 7.6. As it originally applied to radionuclides, the unit of concentration in Equation 7.4 was changed from pCi/L to mg/L. The mineral-water distribution (or fractionation) coefficient (K_d) for each metal was either adopted from default values in RESRAD v.6.4, Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil (Argonne 1993) or, if unavailable, the soil retention fraction (R_s in Equation 7.4) was conservatively assumed to be one. End of Production water quality estimates (Table 7.3-8) were used for the non-radiological parameter source term estimates.

The steady-state soil concentrations of metals are compared to EPA Region 9 generic Soil Screening Levels (SSLs) in Table 7.3-8. Each SSL represents a $1*10^{-6}$ excess cancer risk posed by non-additive ingestion of each of the metals or inhalation of chromium as chromium (VI).

The framework for EPA SSLs is presented in “Soil Screening Guidance: User’s Guide,” EPA/540/R-018, dated July 1996 (EPA 1996). The soil screening guidance states that the prevalent exposure pathway to metals in soil is direct ingestion. The guidance recommends that dermal contact need not be considered for metals and inhalation of fugitive dust need only be considered for chromium (VI).

The assumptions used to derive the generic SSLs appeared to be reasonable for the Dewey and Burdock land application areas. The equation used to determine the screening level for ingestion of non-carcinogenic contaminants in a residential use endpoint is:

$$ScreeningLevel(mg/kg) = \frac{THQ\ x\ BW\ x\ AT\ x\ RfD_o\ x\ 365}{10^{-6}\ x\ EF\ x\ ED\ x\ IR}$$

Where:

THQ	=	Target hazard quotient, default value is 1
BW	=	Body weight, default value is 15 kilograms
AT	=	Averaging time, default value is 6 years
RfD_o	=	Oral reference dose, mg/kg-d, chemical specific
EF	=	Exposure frequency, default value is 350 d/yr
ED	=	Exposure duration, default value is 6 years
IR	=	Soil ingestion rate, default value is 200 mg/d

The equation used to determine the screening level for ingestion of carcinogenic contaminants in a residential use endpoint is:

$$ScreeningLevel(mg/kg) = \frac{TR\ x\ AT\ x\ 365}{SF_o\ x 10^{-6}\ kg/mg\ x\ EF\ x\ IF}$$

Where:

TR	=	Target cancer risk, default value is $1*10^{-6}$
AT	=	Averaging time, default value is 70 years
SF_o	=	Oral slope factor, $(mg/kg\text{-}d)^{-1}$, chemical specific
EF	=	Exposure frequency, default value is 350 d/yr
IF	=	Age-adjusted soil ingestion factor, default value is 114 mg-yr/kg-d

The equation to determine the screening level for inhalation of carcinogenic contaminants (chromium only) in a residential use endpoint is:

$$ScreeningLevel(mg/kg) = \frac{PEF\ x TR\ x\ AT\ x\ 365}{URF\ x 1000\ \mu g/mg\ x\ EF\ x\ ED}$$

Where:

PEF	=	Particulate Emission Factor, default value is $1.32*10^{9}$ m^3/kg
TR	=	Target cancer risk, default value is $1*10^{-6}$
AT	=	Averaging time, default value is 70 years
URF	=	Inhalation unit risk factor, $(\mu g/m^3)^{-1}$, 0.084 for chromium (VI) particulates

EF = Exposure frequency, default value is 350 d/yr
ED = Exposure duration, default value is 30 years

As shown in Table 7.3-8 no metals with steady state surface soil concentrations exceed their respective SSL at either location.

Table 7.3-8: Steady-State Metals Concentrations and Respective SSLs in Land Application Area Surface Soils

	Concentration in Applied Water (mg/L)		Concentration in Soil (mg/kg)		
Metal	**Dewey**	**Burdock**	**Dewey**	**Burdock**	**EPA Region 9 SSL (mg/kg)**
Arsenic	0.01	0.01	0.32	0.19	0.39 ca[a]
Barium	0.32	0.32	10.4	8.0	15,000
Cadmium	0.33	0.33	10.5	8.2	70[b]
Chromium	0.325	0.325	10.3	8.0	Chromium (III) insoluble salts: $1.2*10^5$ Chromium (VI) particulates: 39 ca[c] Chromium, Total (1:6 ratio Cr VI : Cr III): 280
Copper	0.272	0.272	8.8	6.8	3,100
Iron	1.1	0.2	35.6	27.6	55,000
Lead	10	10	324	251	400
Nickel	0.29	0.29	9. 4	7.2	1,600[d]
Selenium	0.2	0.2	6.5	5.0	390
Vanadium	10	6	324	151	390

Notes:
a. ca= cancer endpoint
b. dietary cadmium
c. exposure via inhalation
d. nickel as soluble salts

7.4 Potential Non-Radiological Effects

NUREG-1569 requires that estimates of concentrations of nonradioactive constituents in effluents at the points of discharge be compared to natural ambient concentrations with applicable discharge standards. There will be two effluents from the project; a gaseous airborne effluent and a liquid effluent.

The gaseous airborne effluent will consist of the ventilated air from the plant's ventilation system, originating from the process vessels and tanks. Radon gas will be present in this effluent as discussed in Section 7.2.1 above. No non-radiological effluents will be present in the gaseous airborne effluent. Non-radioactive airborne effluents from the project will be composed of fugitive dust from site roads and well field activities. Dust suppressants will be used to mitigate fugitive dust emissions if deemed necessary depending on-site conditions.

Powertech (USA) is currently considering two scenarios for liquid effluent disposal. The first involves management of liquid waste using Class V deep disposal wells. The second involves use of land application. As the project is moves forward, the feasibilities of either scenarios or some combination of two scenarios will be evaluated and a determination will be made based on effectiveness, implementability, and cost.

7.5 Potential Effects of Accidents

The NRC has determined that the effects of all accidents that are the most probable to occur at an ISL facility, are minor, provided that effective emergency procedures exist and are utilized in the event of an accident, and that personnel are properly trained to handle the situations. When compared with conventional underground and open pit mining methods, accidents associated with ISL uranium production typically have far less severe consequences. An assessment of potential accidents are discussed in the following sections.

7.5.1 Potential Chemical Risks

The chemicals to be utilized in uranium processing at the project are listed in Section 3.2.8 along with a description of chemical storage and spill containment. Chemicals have the potential to impact radiological and non-radiological safety. Chemicals that have the potential to impact radiological safety include hydrochloric acid, sulfuric acid, hydrogen peroxide, and sodium hydroxide. Oxygen, because of its ability to support combustion, also requires special handling. In all instances, process controls and preventative safety measures minimize the risk of increased radiological exposure or release. Each chemical storage and feeding system will be designed to safely store and accurately deliver process chemicals to the process delivery points. All chemical storage tanks will be clearly labeled to identify contents. Design criteria for chemical storage and feeding systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Powertech (USA) employees and members of the public, both with regard to the specific chemicals and with regard to the potential release of radioactive materials in the event of an accident.

Any negative impact to radiological safety from use of these chemicals would be due to accidents, improper use, or human error. Nevertheless, these chemicals would only indirectly cause a radiological hazard as they do not contain radiological materials themselves. Additional information on safe storage and use of chemicals with potential to impact radiological safety is provided in Section 3.2.8.

Potential non-radiological accident impacts include high consequence chemical release events for both workers and nearby populations. The likelihood of such release events would be low based on historical operating experience at NRC-licensed facilities, primarily due to operators following commonly-applied chemical safety and handling protocols. The overall potential impact to public and occupational health and safety of ISR operations that utilize these chemicals has been determined to be SMALL to MODERATE (NUREG-1910, v2, p. xliii).

7.5.1.1 Site-Specific Conditions Potentially Affecting Chemical Risk

Additional measures that address site-specific conditions are described below.

Freezing Temperatures

Outdoor winter temperatures at the project area will at times be below freezing. All tanks and pipelines that contain fluids subject to freezing will be heat traced to maintain the contents above the freezing point of the material. Header houses, valve vaults, and well head covers will contain electric heaters to prevent freezing temperatures from occurring in these structures.

Windstorms and Winter Storms

All facilities, including buildings, storage tanks, and well head covers, will be designed and constructed to withstand the highest wind velocities that are reasonably expected to occur within the project area. During winter months, storms with high winds and snowfall may cause blizzard conditions, but these events do not present a higher potential for chemical accidents. Delivery of chemicals will be delayed until safe driving conditions exist. Care will be taken not to let the amount of chemicals on hand be reduced to levels that make it urgent to obtain more chemicals.

7.5.2 Potential Groundwater Contamination Risks

Horizontal and vertical lixiviant excursions have the potential to contaminate the groundwater in the production aquifer or the overlying or underlying aquifers.

7.5.2.1 Potential Recovery Solution Excursions

Potential groundwater quality impacts from excursions are discussed in detail in Section 7.2.5.3. Excursions have the potential to contaminate adjacent non-exempt aquifers with constituents that have been mobilized during the ISL process. There are two types of excursions: vertical and horizontal. A vertical excursion is movement of solution into overlying or underlying aquifers. A horizontal excursion is a lateral movement of leach fluids outside the production zone of the orebody aquifer.

The potential impacts of horizontal and vertical excursion could be significant. Monitoring wells will be installed within and around the production zone to ensure timely detection of horizontal excursions. Monitoring wells will be installed in the overlying and underlying aquifers to ensure timely detection of vertical excursions.

By properly designing and pump testing each well field and its associated monitor well network, including specifically addressing those areas having the greatest potential for excursions, Powertech (USA) will minimize the risk of excursions and minimize the potential impacts resulting from excursions. By routinely sampling monitor wells for changes in water level and concentrations of the highly mobile and conservative excursion parameters of chloride, total alkalinity and conductivity, Powertech (USA) will ensure that any potential excursions are identified and corrected quickly. As described on page B-75 of the Moore Ranch Final SEIS (NUREG-1910, Supplement 1, Appendix B), "An excursion is defined as an event where a monitoring well in overlying, underlying, or perimeter well ring detects an increase in specific water quality indicators, usually chloride, alkalinity and conductivity, which may signal that fluids are moving out from the wellfield…The perimeter monitoring wells are located in a buffer region surrounding the wellfield within the exempted portion of the aquifer. These wells are specifically located in this buffer zone to detect and correct an excursion before it reaches a USDW…To date, no excursion from an NRC-licensed ISR facility has contaminated a USDW."

7.5.3 Potential Well Field Spill Risks

The failure of a process pipeline within the well field could result in the discharge of pregnant or barren lixiviant or restoration fluid to the surface. In order to minimize the amount of liquid that is lost should a failure occur, high and low pressure alarms and shutoffs as well as flowmeters will be installed on pipelines between the well field and the CPP. Operating flow rates and pressures of all injection wells, production wells, and associated buried piping systems will also be monitored and recorded on a daily basis. The CPP and Satellite Facility control rooms will both receive the pressure and flow data transmitted from the well fields, trunklines, and header houses. This information will provide the plant operators access to instantaneous data on well field operating conditions, enabling them to respond appropriately to unexpected or upset conditions, and allow them to direct well field operators to specific locations where immediate attention is needed. Should a failure occur and the amount and/or concentration of the process fluid lost constitute an environmental concern, then the affected area will have the contaminated soil surveyed and removed for disposal. Pipeline failure is minimized by burying the pipeline below the frost line, approximately five feet below ground surface, and inspecting and testing the piping prior to burial. Pressure test results for the piping will be documented. Corrosion free high density polyethylene (HDPE) or similar piping will be used to further reduce the chance of pipeline failure.

Small leaks at pipe joints and fittings in the header houses or at wellheads may occur occasionally. These leaks may drip process solutions onto the underlying soil until they are identified and repaired. Powertech (USA) will implement a program of continuous well field monitoring by roving well field operators including periodic inspections of each well, in order to identify and remedy small leaks. As described in Section 3.2.12, each header house will also include a sump equipped with a water level sensor so that if a leak occurs, and the water level approaches a preset level, the sensors will cause an automatic shutdown of the header house. Small leaks rarely result in contamination of the underlying soil. Following repair, Powertech (USA) will survey the affected soil for contamination, and, if contamination is detected, the soil will be appropriately removed.

7.5.4 Potential Transportation Accident Risk

All shipments to and from the PAA will be transported by only licensed and certified commercial drivers and subject to both federal and state transportation regulations. Four classifications of shipments will be sent or received during pre-operational and operational phases of the project:

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

Potential impacts would differ according to material type, quantities, and concentrations. The separate scenarios are discussed below. The following section discusses the transportation risks of the four materials classified above.

7.5.4.1 Potential Accidents Involving Yellowcake Shipments

The yellowcake will be transported in 55-gallon (208-L) drums to a conversion facility in Metropolis, Illinois or Port Hope, Ontario, Canada, for refining and conversion. A specialized third party transportation company (such as Tri-State freight service) will transport the yellowcake from the project to a conversion facility rather than Powertech (USA). Specific routes are to be determined upon agreements made within the transportation companies' contract. This company will meet all safety controls and regulations promulgated by 10 CFR 71.5. With a production rate of 1,000,000 lbs per year at the Proposed Action Area, shipments are estimated to weigh approximately 40,000 lbs per load and would require an estimated 25 shipments per year. Smaller or partial loads could require additional shipments.

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

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

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

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

The potential environmental impacts from the shipment of yellowcake could result from an accident and impact primarily the top soil in the area contaminated by the spill and the subsequent modification to the vegetation structure and the salvage of the top soil.

7.5.4.2 Potential Accident Involving Ion Exchange Resin Shipments

The project will have resin stripping facilities, therefore shipments involving uranium-loaded IX resin may be transported to the PAA. The consequences are likely to be lower for trucks transporting barren or eluted resin because the risk of contamination is minimal. Both barren and eluted resin shipments will be handled in accordance with NRC and DOT regulations. The same general shipping procedures outlined for the shipment of yellowcake (Section 7.5.4.1) will be followed for resin shipments.

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

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

7.5.4.3 Potential Accidents Involving Shipments of Process Chemicals and Fuels

Over the course of the operational life of the facility a number of shipments of chemical, fuel, and supplies will be made each week. Process chemicals delivered to the project site will include carbon dioxide, oxygen, salt, soda ash, barium chloride, hydrogen peroxide, sulfuric acid, hydrochloric acid, caustic soda (sodium hydroxide) and fuel. All applicable DOT hazardous materials shipping regulations and requirements will be followed during shipment of process chemicals and fuel to prevent a possible transportation accident. Analyses of

documented accidents involving shipments have shown that secure containers have prevented spills (NMA, 2007).

7.5.4.4 Potential Accidents Involving 11e.(2) Byproduct Material

The disposal of all solid 11e.(2) byproduct waste generated during operations will be transported to an appropriately licensed disposal facility. Most of the solid waste shipping will occur during the site reclamation and decommissioning stage. The probability of an accident while transporting 11e.(2) waste for any given trip is similar to the probability discussed in Section 7.5.4.1. The potential risks, however, for exposure are less because 11e.(2) waste is generally less radioactive than dried yellowcake and much of the waste will consists of solid material that in the event of an accident would be easy to contain. All applicable DOT shipping regulations and requirements will be followed before and during shipment of 11e.(2) wastes to prevent a possible transportation accident.

7.5.5 Potential Natural Disaster Risk

NUREG/CR 6733 evaluates potential risks associated with ISL facilities for the release of radioactive materials or hazardous chemicals due to the effects of an earthquake or tornado strike. The NRC determined that in the event of a tornado strike, chemical storage tanks could fail resulting in the release of chemicals. NUREG-0706 analyzed the risk from a tornado strike, which determined that ISL facilities were not designed to withstand tornado strength winds and assumed that an inventory of 45,000 kg of yellowcake was present on-site and that 15 percent (11,400 kg) or 26, 55-gallon drums of the yellowcake was dispersed by the tornado. The model assumes that all the yellowcake was in a respirable form and was carried by the tornado to the project's site boundary. According to the model, the maximum 50-yr. dose to an individual's lung would be 8.3×10^{-7} rem and located approximately 2.5 miles from the mill. NUREG-6733/CR concluded that the risk of a tornado strike on an ISL facility was very low and that no design or operational changes were necessary to mitigate the potential risks, but that it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident. Considering the relative remoteness of the proposed Dewey-Burdock Project, the potential consequences of a tornado strike would be considerably less than if the facilities were in a more populated area.

Nevertheless, there are risks to workers that must be addressed. Powertech (USA) will prepare and have available onsite for NRC inspectors an Emergency Response Plan that will contain emergency procedures to be followed in the event of severe weather or other emergencies. Included in the plan will be procedures for notification of personnel, evacuation procedures, damage inspection and reporting. It will also address cleanup and mitigation of spills that may result from severe weather. In advance of preparing the Emergency Response Plan, Powertech (USA) offers the following discussion on these issues.

Initially, Powertech (USA) will provide adequate training to its employees and visitors regarding communication systems used at the facilities. In the event of a report of a tornado sighting in the vicinity of the facility, the RSO, RST and/or Safety Engineer will ensure that the proper alarm (preset signal) has been sounded at both the Burdock and Dewey facilities. Additionally, all supervisors will be personally contacted via phone or radio and advised of the emergency. The supervisors and radiation safety staff will direct the employees' evacuation to one or more previously-specified nearby locations. Once it is safe to access the facilities, supervisory staff and radiation safety staff will begin the process of assessing potential damage to the facilities, including header houses and well heads. This process will include radiological surveys and assessment of potential non-radiological hazards as well. NRC, DENR, BLM and other regulatory agencies as appropriate will be notified and advised of the damage, if any was observed. After consultation with the regulatory agencies the cleanup and mitigation efforts will commence.

The NRC determined that the radiological consequences of materials released and dispersed due to earthquake damage at an ISL facility were no greater than for a tornado strike. NUREG-0706 determined that mitigation of earthquake damage could be attained following adequate design criteria. NUREG/CR-6733 concluded that risk from earthquakes is very low at uranium ISL facilities and that no design or operational changes were required to mitigate the risk, but that it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

All buildings, structures, foundations, and equipment will be designed in accordance with recommendations in the latest versions of the International Building Code and ASCE-7 published by the American Society of Civil Engineers. Maps published in ASCE-7, and the latest version of the USGS Earthquake Ground Motion Tool, along with information regarding soil characteristics provided by the project professional geotechnical engineer, will be used to determine seismic loadings and design requirements.

7.5.6 Potential Fire and Explosion Risk

Accident Consequences – Fires and Explosions

An explosion, although unlikely, could result from: a prematurely sealed drum of yellowcake, in a dryer, from the use of propane in the thermal fluid heater or space heaters, or from the mixing of oxygen gas with combustible materials. Of these, an explosion from the drum of yellowcake has the greatest potential to impact radiological safety of the workers. An explosion in a sealed drum would be contained within the dryer room. Powertech (USA) will develop an SOP for measuring the temperature in yellowcake drums prior to drum sealing.

According to the NRC, multiple hearth dryers pose a greater hazard than the vacuum dryers that will be used by Powertech (USA) (NUREG-1910). Multiple hearth dryers operate at higher temperatures and may be directly fed with gas. The vacuum dryers proposed for the Dewey-Burdock Project operate at lower temperatures and are not directly fed by gas. They therefore pose less of a hazard for explosion. In the unlikely event of an unmitigated explosion accident of a yellowcake dryer, doses to the workers could have a MODERATE impact depending on the type of accident, but exposure to the general public would result in a dose below the 10 CFR Part 20 public dose limit, resulting in only a SMALL impact to the public (NUREG-1910, pg. 4.2-56).

Preventative and Mitigation Measures – Fires and Explosions

As noted in Section 3.2.8, the design criteria for chemical storage and feeding systems includes applicable sections of the International Building Code, International Fire Code, OSHA regulations, RCRA regulations, and Homeland Security regulations. Propane fired heating devices will be installed to meet applicable NFPA/FM safety standards. Additional measures for preventing fires and explosions within process facilities include:

- As noted in Section 3.2.8.6, the oxygen tanks will be located a safe distance from the CPP and other storage tanks and will be designed to meet industry standards of NFPA-50.
- Cleaning of equipment for oxygen storage and conveyance systems will follow the standards specified in CGA G-4.1.
- Powertech (USA) will develop emergency response procedures for oxygen accidents. All employees who may be exposed to hazards associated with oxygen will be properly trained with regard to the hazards, accident prevention and mitigation, and emergency response procedures.

- Header houses will be equipped with fans to provide continuous ventilation in order to prevent buildup of oxygen.
- The oxygen lines to each header house will be equipped with automatic low pressure shut-off valves to minimize the delivery of oxygen through a broken pipe or a valve stuck in the open position, which could potentially supply oxygen to a fire.
- Procedures will be in place for confined space work or hot work for monitoring of oxygen build-up prior to start of work.
- Fire extinguishers will be placed at accessible locations in all buildings and vehicles for quick response and training will be provided for appropriate personnel in use of fire extinguishers.
- Powertech (USA) personnel and local emergency responders will receive training for responding to a fire or explosion.
- The CPP facilities are designed to contain and reduce the exposures to individuals in the event of an accident. Emergency response procedures will be implemented and employees will be directed as to what actions to perform in the event of an accident. For instance, a respiratory protection program will be in place and will be executed as necessary for worker protection during accident assessment and cleanup phases. In addition to the above mentioned protections other safeguards and mitigatory protocols are always in place during operation of a CPP facility. For example, a bioassay program for worker safety and contamination control programs involving personnel survey, clothing survey and equipment survey before release to unrestricted areas are common practices workers are subject to on a regular basis. These types of protocols are also utilized to assess if an accidental exposure took place during the course of an unintentional incident.

Preventative and Mitigating Measures – Wildfire

In order to protect facilities from wildfires, all facility buildings will be located within an area that is maintained in a vegetation-free state by the use of a crushed aggregate or asphalt surface and by appropriate weed-control measures. The creation of this buffer zone is expected to prevent fire from damaging equipment that could lead to a chemical accident by acting as a firebreak.

Within the well fields, vegetation will be controlled around each header house and around each well head cover to reduce the amount of combustible material adjacent to these structures. In the event of an approaching wildfire, operators will be trained to shut down well field operations and, if necessary, to evacuate facilities until the danger to personnel has passed. Damage, if any, will be assessed and remediated prior to re-starting operations.

Powertech (USA) will maintain firefighting equipment on site and will provide training for local emergency response personnel in the specific hazards present in the project area.

The emergency response plan will include descriptions of the following provisions of 29 CFR Part 1910:

- Notification and evacuation procedures
- Personal protective equipment
- General firefighting safety rules
- Reporting procedures
- Electrical and gas emergencies

7.5.7 Potential Major Pipe or Tank Rupture Risk

Potential Major Pipe or Tank Rupture in the CPP or Satellite Facility

a. Preventative measures: Facilities will be designed and operated according to 40 CFR Part 68. In addition, Powertech (USA) will comply with 40 CFR Part 355 in disclosing the reportable quantities of sulfuric acid, hydrochloric acid and sodium hydroxide, the only chemicals used in the project area that are expected to be present in quantities greater than the minimum reportable amounts. Preventative measures will also include routine inspection, installation of safety devices to prevent over pressurization or excessive level, use of tanks and vessels that meet applicable ASME and/or ASTM codes, and proper engineering design of tanks and supporting structures, foundations, and footings.

b. Consequences: The rupture of a major pipe or tank within either the CPP or Satellite Facility would result in the release of process liquids onto the floor of the facility. The spilled material will be contained by concrete curbs and will flow to the trench drains and sumps (equipped with level alarms), where it will be pumped to the appropriate tank or disposal system. Alternatively, the spilled material will be transferred from the sumps to the Central Plant Pond for reprocessing prior to eventual disposal. In the event of a total electrical failure, such that no pumps would be operational, a spill due to a vessel failure will be contained within the building in which the vessel failure occurred.

c. Actions used to stop chemical accidents: Personnel will be trained in the hazards associated with process chemicals and solutions present at each facility and the proper procedure to follow in the clean-up of a spill of the materials within the plant facilities. In particular, for tank ruptures, operators will be trained to use personal protective equipment and to close valves on any pipelines connected to the ruptured tank. In the case of a pipe rupture, personnel will be trained to shut down pumps and close valves in order to isolate the section of pipe containing the rupture from other parts of the process. Powertech (USA) will also train local emergency response personnel in the potential hazards associated with the facility.

Capacities of Sumps and Curbed Areas

The CPP and Satellite Facility will be designed with trench drains, sumps, and a concrete curb at the perimeter of the floor designed to contain the contents of the largest vessel in the facility. For the CPP, the largest liquid-containing vessel is the yellowcake thickener, which will have an operating volume of 5,000 ft^3. For the Satellite Facility, the largest liquid-containing vessel will be the utility water tank, with a volume of 2,139 ft^3. For both facilities, a containment curb along the perimeter wall of each building slab with internal trench drains and sumps will be designed to contain a spill of at least 200% of the largest liquid-containing tank or vessel volume in each facility. Sumps and sump pumps will be operable for the removal of spilled materials to waste holding tanks or the Central Plant Pond and ultimately to the liquid waste disposal system. For additional information on the capacities of curbed areas, refer to Section 5.7.1.3.

7.6 Potential Economic and Social Effects of Construction and Operation

The following section highlights potential socioeconomic impacts of the project to Custer and Fall River Counties. A cost benefit analysis for the project is presented in section 9.0.

7.6.1 Construction

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

Table 7.6-1 shows the potential direct, indirect and induced effects on Custer and Fall River Counties' employment. The direct employment effects refer to the employment directly generated by the project. For the initial construction phase in years 2009 to 2010, the IMPLAN model estimated 171 additional non-payroll workers hired in Custer and Fall River Counties based on the estimated 86 payroll workers engaged directly in construction activities and the $45.8 million in non-payroll capital expenditures incurred by the project per year.

Table 7.6-1: Employment Effects of the Project in Custer and Fall River Counties

Years	Employment			
	Direct	Indirect	Induced	Total
2009-2010	86	45	126	257
2011-2017	84	36	35	155
2018-2024	18	3	3	24

Potential indirect effects pertain to the inter-industry effects from the direct effects and could include increased labor demands, goods and services required to support the ISL project (e.g. retail and restaurant staff). In addition, new workers living within Custer and Fall River

Counties would spend their income locally, which would induce additional income and employment. The sum of potential direct, indirect and induced effects represents the total potential employment impacts of the project.

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

7.6.2 Operation Workforce

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

For the operation phase of the project (2011-2017), the IMPLAN model estimated 71 additional non-payroll workers will be hired in Custer and Fall River Counties based on the estimated 84 payroll workers engaged directly in the operation activities and the $21.2 million in non-payroll capital expenditures incurred by the project per year. The economic impacts of these newly created 155 jobs during the operation phase of the project are not limited to Custer and Fall River Counties, but will likely affect the surrounding Counties of Weston, Niobrara, and Pennington because of increased commerce and capital exchange within the region.

7.6.3 Effects to Housing

Because of the project's close proximity to the more populated communities of Custer and Hot Springs, South Dakota and Newcastle, Wyoming with a combined population greater than 9,000 people, it can be assumed that much of the workforce would come from these localities. The remaining workforce would likely relocate from the surrounding area (e.g., South Dakota, Nebraska and Wyoming). The IMPLAN model results show that during the two year constructional stage 2010-2012, the project has the potential to sustain the creation of 257 new jobs for two years. During the following seven year operation stage the project has the potential to sustain the creation 155 jobs for seven years, and 24 jobs over the final seven years.

In the unlikely event that the entire direct payroll and non-payroll workforce relocated to Custer and Fall River counties, the population increase for the three stages of operations would be 619, 374 and 58, based on the average family size in South Dakota of 2.41 as of 2006. This increase

in population would account for an increase of 6.9 percent (total population 15248) in the total population of Custer and Fall River counties. This is a very conservative estimate because it is likely that a large percentage of the workforce for operation and reclamation will be sourced from the existing workforce, thereby reducing the total population increase substantially. The potential impacts associated with an increase in population are expected to be dispersed because of the remoteness of the project site and the phased nature of construction, operation and reclamation. While this is a moderate increase in the overall percentage of the local population, this influx of immigration could be partially mitigated by implementing a preferential hiring scheme and using regional educational/training institutions to help train workers and to ensure that as many of the local residents are hired as possible.

7.6.4 Effects to Services

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

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

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

7.6.5 Effects to Traffic

There are only a few residences in the vicinity of the proposed project. Most of the land in the surrounding a 2 km radius of the project is devoted to rangeland. Other land uses include grazing, crop land, hunting and wildlife habitat. As a result of the low population density of the area surrounding the project site, the anticipated limited use of large machinery and vehicles and the infrequent movement of transport vehicles to and from the project site, no significant noise or congestion impacts are anticipated within the surrounding 2 km area during operations. There will be some increased traffic, noise and dust on the county road between the project site and Edgemont during construction activities. However, these potential impacts will be of short duration.

7.6.6 Economic Impact Summary

According to the Cost-Benefit Analysis in Section 9, the most significant benefits of the project are its potential to sustain the creation of 257 new jobs during construction, 155 jobs during operation, and 24 jobs during reclamation, all of which include the direct, indirect and induced effects on the local economies. In addition, an estimated $91.6 million during construction will be spent on non-payroll expenditures, $148.4 million during operation and 14.0 million during reclamation; and approximately $35.1 million in state and local tax revenue and $186.7 million in value added benefits are expected to be generated over the life of the project (Table 7.6-2) as a result of the project.

Table 7.6-2 summarizes the associated short-term and long-term cost of the proposed project. Impacts to the regional housing market should be minimal because of the large percentage of local workers, impacts to schools and public facilities should be negligible because of their present ability to absorb any associated regional influx, and the impact of noise and additional traffic presents little or no change compared to the no action alternative. Due to the remote location of the project Site and minimal surface disturbance, impacts to recreational activities and aesthetic values within the area should be negligible.

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

Table 7.6-2: Summary of Benefits and Costs for the Project

Benefits	Costs
▪ **Value Added** $186,697,204 ▪ **Tax Revenue** $35.1 million ▪ **Potential to create temporary and permanent jobs** 257 jobs over two years (2009-2010) during construction 155 jobs over seven years (2011-2017) during operation 24 jobs over seven years (2018-2024) during reclamation ▪ **Increased knowledge of the local environment and natural resources**	▪ **Housing Impacts** Little or no change ▪ **Schools and Public Facilities** Negligible ▪ **Noise and Congestion** None ▪ **Impairment of Recreation and Aesthetic Values** Negligible ▪ **Land Disturbance** Minor ▪ **Groundwater Impacts** Controlled through mitigation ▪ **Radiological Impacts** Controlled through mitigation

7.7 Environmental Justice

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

As shown in Table 7.7-1, minorities make up less than six percent of the total population for Custer and Fall River Counties, much less than the state average of more than 11 percent and no concentration of minorities was identified to reside near the PAA; therefore, no disproportionate impacts could occur to minority groups.

Per capita income level based on 1999 dollars was 17,945 for Custer County and $17,048 for Fall River County; these numbers are near the State average of $17,562. The median income in 2000 was $36,303 for Custer County and $29,631 Fall River compared with $35,282 for the State average, all well above the 2006 poverty level of $20,614 for a family of four family member household. The poverty rate in Custer County was 9.4 percent and 13.6 percent in Fall River County. Compared to the state-wide average of 13.2 percent, Fall River's poverty rate is

only slightly higher, while Custer County is well below the state-wide; therefore, there is not be a disproportionate concentration of low-income populations within the study area compared to the State as a whole.

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

Table 7.7-1: Project-Area Housing Unit Statistics - 2000

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

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

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8.0 Alternatives to Proposed Action

8.1 No-Action Alternative

Under the provisions of the National Environmental Policy Act (NEPA), one alternative that must be considered in each environmental review is the no-action alternative. In this case, the no-action alternative would be to not build or license the Dewey-Burdock ISL facilities. This alternative will provide a baseline from which to compare the potential impacts of the other action alternatives.

8.1.1 Potential Impacts of the No-Action Alternative

The potential impacts of the no-action alternative include, the lost opportunity to produce a large resource of energy production supply. In addition beneficial impacts resulting from stimulated economic growth, income and tax generation will not be realized. The proposed project represents a significant new source of domestic uranium supplies that are essential to provide a continuing and economic source of fuel to power generation facilities. As discussed in the Cost-Benefit Analysis, Section 9, the Dewey-Burdock Project is expected to provide a significant beneficial economic impact to the local economy.

8.2 Proposed Action

While the PAA encompasses 10,580 acres (4,282 ha), the land potentially impacted by the Proposed Action would be approximately 68 acres (27 ha) (facilities, piping, ponds, well fields and roads) in year one, and the potential impacts will be intermittent. The average disturbance per year for the life of the proposed project (production to restoration) is estimated at 77 acres (31 ha). If the maximum area for land application of treated wastewater is included in the footprint of the Proposed Action, then approximately 384 acres (155 ha) would be affected per year on average during the life of the mine. During the first year of the Proposed Action, approximately 110 acres (44 ha) would be affected. A description of the proposed ISL facilities is provided in Section 3.1.

8.3 Reasonable Alternatives

8.3.1 Location of Proposed Facilities

Locations of the proposed CPP and the SFs were strategically chosen based on specific site area, proximity to historical and current reserves within the northern Dewey and southern Burdock areas, environmental both historical disturbance, wildlife concerns and the geology of the area.

The CPP would be constructed in Section 2, T7S, R1E of the Burdock action area and the SF would be located in Section 29, T6S, R1E of the Dewey action area (see Figures 3.1-1and 3.1-2).

- Based on the TVA data and current Powertech (USA) data, the location of both the CPP and the SFs locations would be approximate to the center of ore reserves located within the action areas in locations that have little potential for ore beneath chosen locations.
- Environmental considerations were noted such as historical surface mines, nesting sites for raptors, drainage issues; the locations chosen do not have these issues.
- There were no issues with the surface or subsurface geology for either the CPP or the SF location.

8.3.1.1 Well Fields and Monitoring Wells

A well field consists of ISL amenable ore zones within a sandstone bounded by an upper and lower hydrologic barrier. In the simplest scenario, there is a single ore zone; and a monitor well ring radially bounds that ore zone, as one of the primary means of ensuring control of leach fluids within a well field. In more complex systems, there may be more than one ore zone stacked vertically within a sandstone, and there may be more than one sandstone, with multiple ore zones stacked vertically (Lost Creek Project, 2007).

Within the Dewey area, there exists at least one area where one production zone overlies another. Section 3.1.3 describes the monitoring well layout and design for this scenario, including monitoring all overlying hydrogeologic units for potential vertical excursions. Section 5.7.8.4.3 provides additional description of perimeter monitoring well spacing and layout for stacked roll fronts.

This monitoring scheme described in Sections 3.1.3 and 5.7.8.4.3 is preferred over other methods such as:

- Multiple Completions

  Completion of wells across multiple sands within the same horizon, using the same wells and the same monitor ring could be an alternative. However, this is not considered an appropriate alternative because of the difficulties of ensuring the injection and production fluids are being efficiently distributed to the various sands in the horizon and of monitoring the performance of the well field.

- Larger Rings Encompassing More Reserves

  The wells are completed in the same manner as the preferred option. Because of the increase in scale, the construction time, evaluation of pump tests, and all other activities associated with installing and producing the well field would increase dramatically. Final restoration/reclamation of the well field would be delayed until all operations for the area were complete. Therefore, this option is not considered the most efficient approach (Lost Creek Project, 2007).

8.3.2 Process Alternatives

8.3.2.1 Lixiviant Chemistry

Powertech (USA) proposes to use gaseous oxygen and carbon dioxide to dissolve the uranium in the ore zone. Alternatives for lixiviant chemistry include ammonium carbonate or sodium bicarbonate/carbonate solutions and acidic leach solutions. While these lixiviant solutions have been used in previous ISL operations, they were rejected for the Dewey-Burdock Project, due to the fact that restoration and stabilization of groundwater to baseline conditions has been shown to be more difficult with these alternative systems.

8.3.2.2 Groundwater Restoration

The proposed groundwater restoration method for the proposed project is based on the successful programs implemented by other projects such as the Cogema Irigaray Restoration Project or Crow Butte Resources, Inc., which have both received regulatory approval for successfully restoring groundwater to previous class of use.

During aquifer restoration, the technology selected will depend on the liquid waste disposal option. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison

Formation will be used to restore the aquifer. Additional information about aquifer restoration methods is provided in Section 6.1.3.

An alternative groundwater restoration method includes the use of bioremediation. Bio-reductants are introduced to invigorate natural bacteria that re-reduce metals to an insoluble state. Bio-reduction has been used successfully to restore the Sweetwater Pit Lake, which originally had uranium concentrations of 8 to 10 mg/L and post remediation the levels were below 5 mg/L. This alternative was considered but eliminated because the effectiveness of this technology is not well documented for aquifer remediation post ISL operations as discussed in NUREG-1910.

8.3.2.3 Waste Management

There are several disposal options for the liquid waste generated during the production and restoration process including brine concentrators, discharge to surface waters, evaporation ponds, waste disposal well, land application, and waste disposal well off-site. The National Pollutant Discharge Elimination System (NPDES) permitting process allows for the discharge of treated liquid effluents to surface waters that meet state and federal water quality standards, but was determined to be a poor use of water resources in a water sensitive region. The sole use evaporation ponds was rejected because of the large surface impoundment area that would be required to evaporate the daily bleed water and the severe winters that would freeze the ponds for several months out of the year, thereby decreasing the evaporation rates. The transportation of liquid waste for disposal at an off-site deep well is another option that was considered but eliminated due to the transportation impacts and practicality of disposing waste out of state. Powertech (USA) considers the use of deep disposal wells and/or land application as the best alternatives to dispose of these types of liquid waste. The deep wells identified by Powertech (USA) will isolate liquid waste generated during the production and restoration processes from any underground source of drinking water (USDW). In both cases, the liquid waste will be treated with additional IX to remove residual uranium, followed by contact with barium chloride to remove radium. Other treatments may also be required before the liquid waste will be injected into Class V deep disposal wells or applied to the land through center-pivot irrigation systems.

Fresh water consumed during drilling, road maintenance, and other related activities will be disposed of appropriately.

Non-radioactive solid and liquid waste will be managed in accordance with existing regulations and disposed of in a landfill that has been permitted under subtitle D of RCRA. Materials that cannot be decontaminated will be disposed of at a licensed 11e.(2) disposal facility.

8.4 Eliminated Alternatives

As part of the alternatives analysis conducted by Powertech (USA) conventional uranium mining both open-pit and underground combined with milling were considered. However, due to economic, environmental, and recovery issues, a detailed analysis was not carried forward at this time.

8.4.1 Open Pit Mining Alternative

Open pit mining requires the removal of all material covering the orebody (overburden) and then the ore itself: The ore would then be transported to a conventional mill for further processing and extraction through grinding, leaching, purifying, concentrating, and drying. From an economic point of view, open pit mining of the relatively low grade and depth of the Dewey-Burdock ore bodies would require a much larger investment than ISL, especially in the early phase, when a significant investment would be required for acquisition of heavy equipment to perform the earthwork to expose the orebody. The overall footprint of the operation would be larger because of greater manpower and material handling requirements. Waste rock piles from excavation of the overburden and the mine pit would make permanent changes to the topography, with a disturbed area approximately three times the area of the orebody mined, in order to maintain slope stability. Potential personnel injury rates and potential radiological exposures at the PAA would also be higher with open pit mining than what would be experienced with ISL. A mill tailings pond would be required to contain the millions of tons of waste produced from the uranium mill'. This tonnage would represent a large volume of radioactive tailings slurry covering a large area of ground surface. Conventional mill operation would involve higher risks of spillage and radiological exposure to both personnel and the environment than those associated with the proposed ISL operations. Open pit mining at the Proposed Action Area would also require dewatering of the pit to depress the potentiometric surface of all aquifers. Large quantities of groundwater would be discharged to the surface. Some of this groundwater contains naturally elevated radium-226 (Ra-226), radon, and uranium, which would have to be

treated before discharge and the residue disposed of as radioactive solid waste (Lost Creek Project, 2007).

8.4.2 Underground Mining Alternative

Underground mining of the uranium resources at the Permit Area would involve sinking of shafts to the vicinity of the ore bodies, horizontally driving crosscuts and drifts to the ore bodies at different levels, physically removing the ore and transporting the mined ore to the conventional mill for further processing. Processes for milling and uranium extraction from underground mined ores would be the same as those for ores mined from the open pit. When one considers the alternative of underground mining, the economic and environmental disadvantage closely parallel those of an open pit mine. These, as stated above, include large amounts of initial investment, permanent changes to the topography (though in a smaller scale than open pit mining because less amounts of waste rock are being generated), generation of a significant amount of mine tailings, increased risks of injury and potential exposure to radioactive materials during mining and milling, and surface discharge of groundwater from mine dewatering with elevated radionuclide concentrations. One major concern for underground uranium mining is the potential exposure of miners to, radon gas if the gas is not continuously vented to the atmosphere. Subsequent land surface subsidence could also occur after the completion of underground mining.

Economic costs and potential environmental impacts associated with open pit and underground mining, clearly show that ISL is the more benign and viable uranium production method to use. The initial investment is lower; the tailings problem is completely eliminated; radiation exposure and potential environmental impacts are minimized; and the groundwater resource is preserved. In addition, because of the reduced costs, lower grade ores can be recovered through ISL than can be recovered from open pit and underground mines (Lost Creek Project, 2007).

The U.S. NRC conducted a comparison of the overall potential impacts of open pit and underground mining with ISL methods in NUREG-0925 and concluded that ISL methods generate lesser potential environmental and socioeconomic impacts. The relative advantages of ISL methods include:

- The degree and the quantity of disturbance to surface area are substantially less than with surface mining.

- No mill tailings are produced and the volume of solid waste is significantly less than conventional milling – typically more than 99 percent less waste is produced with ISL.
- The elimination of airborne emissions from overburden stockpiles or tailings stockpiles and the crushing and grinding processes, which are required for conventional mining.
- Exposure to radionuclides is markedly reduced with ISL methods because less than 5 percent of the radium in an orebody is brought to the surface compared with up to 95 percent with conventional mining techniques.
- Because of the lack of tailings and other significant sources of solid waste ISL facilities can readily be decontaminated and returned to unrestricted use within a relatively short time frame (12-15 years).
- ISL facilities typically consume much less water than conventional mining and milling, on the order of 1 percent of their production flow.
- The socioeconomic advantages of ISL include:
  - Lower grade ores can be mined
  - Requires less capital investment
  - Provides a safer working environment for the miner
  - Decreases amount of time before production begins and
  - Requires a smaller workforce

8.5 Cumulative Effects

8.5.1 Future Development

Powertech (USA) has identified other potential ore bodies near the proposed project region that may be developed. Development of these facilities is dependent upon further site investigations by Powertech (USA), as well as the viability of the uranium market. If the ore bodies and market prove to be favorable, Powertech (USA) may submit applications for permits to develop these additional resources.

8.6 Comparison of the Predicted Environmental Impacts

Table 8.6-1 outlines the predicted environmental impacts of the proposed project (Section 8.2) compared to the no-action alternative (Section 8.1), the process alternatives (8.3) and the mining alternatives (8.4). Potential environmental impacts are discussed in greater detail in Section 7.0.

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Table 8.6-1: Comparison of Environmental and Socioeconomic Impacts based on Proposed Action and Alternatives

Impacts of Operation	Proposed Action	Process Alternatives		Mining Alternatives		No-Action Alternative
		Alternate Lixiviant Chemistry	Alternate Waste Management	Open-pit mining with a conventional mill	Underground mining with a conventional mill	
Land Surface Impacts	Minimal temporary potential impacts to the well field areas; significant temporary disturbance confined to a small portion of the proposed project site	Same as Proposed Action	Same as Proposed Action	Significant land disturbance with the potential for portions of the land surface to remain highly altered	Same as the open pit alternative	None
Land Use Impacts	Temporary loss of agricultural production (grazing livestock) and wildlife habitat within the PAA for the duration of the proposed project	Same as Proposed Action	Same as Proposed Action	Land disturbance increases considerably and time required for reclamation is more extensive; Entire site may not return to unrestricted use	Same as the open pit alternative	None
Transportation Impacts	Minimal impact on current traffic levels	Same as Proposed Action	Same as Proposed Action	The traffic volume elevates substantially due to increased employment and vehicle requirements and considerable more opportunity for higher radiation exposure to the public due to transporting of uranium ores over public roads.	Same as the open pit alternative	None
Geology and Soil Impacts	No geologic impacts; temporary impacts to the soils from disturbance; possible impacts to soil from land application of treated wastewater	Same as the Proposed Action	Similar to the Proposed Action with minimal temporary soil impacts in disturbance areas from wind and water erosion	No geologic impacts; more potential land disturbance due to the possibility of long-term open pit mining	Same as the open pit alternative	None
Surface Water Impacts	None	None	None	Possible contamination of surficial water could result with the use of ponds	Possible contamination of surficial water could result with the use of ponds	None
Groundwater Impacts	Slight consumption of ore zone groundwater	Similar to Proposed Action but with increased difficulty in restoring water quality to baseline conditions	Same as the Proposed Action	Ore zone aquifer will be dewatered in order to mine	Ore zone aquifer will be dewatered in order to mine	None

Table 8.6-1: Comparison of Environmental and Socioeconomic Impacts based on Proposed Action and Alternatives (cont'd)

Impacts of Operation	Proposed Action	Process Alternatives		Mining Alternatives		No-Action Alternative
		Alternate Lixiviant Chemistry	Alternate Waste Management	Open-pit mining with a conventional mill	Underground mining with a conventional mill	
Ecological Impacts	Would only disturb ~ 108 (without land application) to 463 (with maximum amount of land application) acres per year over the life of the proposed project with no substantial impact on the ecological or biological diversity	Same as the Proposed Action	Same as the Proposed Action	Similar to the Proposed Action, but considerably more time would be required for reclamation	Same as the open pit alternative	None
Air Quality Impacts	An increase of 10 tons per year of particulates due to increased traffic	Same as the Proposed Action	Same as the Proposed Action	Total dust emission would be increased significantly due to increased traffic and crushing and grinding processes	Same as the open pit alternative	None
Noise Impacts	Slight increase over background noise levels	Same as the Proposed Action	Same as the Proposed Action	Significant increase in noise levels due to explosions, excavation' and crushing and grinding of rock	Significant increase in noise levels due to crushing and grinding processes	None
Historical and Cultural Impacts	None	None	None	None	None	None
Visual/Scenic Impacts	Moderate and temporary impact; Well fields and Plants would negatively affect the aesthetics	Same as the Proposed Action	Same as the Proposed Action along with evaporation ponds that would further negatively affect the aesthetics	Large and temporary impact; open pit disturbs much more land area and requires much more heavy machinery that would negatively affect the aesthetics	Large and temporary impact; Mill, tailings pond, and increased use of heavy machinery would negatively affect aesthetics	None
Socioeconomic Impacts	Increased economic impact of $307M and the potential for 436 temporary and permanent jobs for Custer and Fall River Counties and the surrounding area	Same as the Proposed Action	Same as the Proposed Action	Similar to the Proposed Action but with an increase in economic impact and jobs created due to the larger workforce and required operation	Similar to the open pit alternative	Loss of positive economic impact of $307M along with potential for 436 temporary and permanent jobs for Custer and Fall River Counties and the surrounding area
Non-Radiological Health Impacts	None	None	None	None	None	None

Table 8.6-1: Comparison of Environmental and Socioeconomic Impacts based on Proposed Action and Alternatives (concl.)

Impacts of Operation	Proposed Action	Process Alternatives		Mining Alternatives		No-Action Alternative
		Alternate Lixiviant Chemistry	Alternate Waste Management	Open-pit mining with a conventional mill	Underground mining with a conventional mill	
Radiological Health Impacts	Estimated maximum TEDE at proposed project boundary is 7.88 mrem y^{-1} compared to the public dose limit of 100 mrem y^{-1} for the land application option; Estimated maximum TEDE at proposed project boundary is 1.12 mrem y^{-1} for the deep well disposal option.	Same as Proposed Action	Same as Proposed Action	Exposure to radioactive material is significantly increased because 95% of the radium in an orebody is brought to the surface	Same as open pit alternative	None
Waste Management Impacts	Generation of liquid and solid waste for disposal	Same as the Proposed Action, but potentially increased liquid waste due to the mobilization of additional hazardous elements in groundwater	Increased generation of 11e.(2) byproduct material for disposal	Waste generated is much greater than ISL and not all material can be removed from the site (e.g., tailings and waste rock)	Same as open pit alternative	None
Mineral Resource Recovery Impacts	Production of domestic energy resource	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action	Loss of domestic energy supply source; the current estimated reserves of uranium within the proposed permit area total 7.6 million pounds U_3O_8 currently valued at $456M (based on spot market price of $60)

8.7 References

Energy Information Administration, "*Summary Production Statistics of the U.S. Uranium Industry*", www.eia.doe.gov/cneaf/nuclear/dupr/usummary.html accessed July 1, 2008.

Energy Information Administration, "*2007 Uranium Market Annual Report*", www.eia.doe.gov/cneaf/nuclear/umar/umar.html accessed July 1, 2008.

Energy Information Administration, "*Uranium Mill Sites Under the UMTRA Project*", http://www.eia.doe.gov/cneaf/nuclear/page/umtra/edgemont_title1.html accessed July 3, 2008.

U.S. Nuclear Regulatory Commission, "*Draft Environmental Statement Related to the Operation of the Teton Project*", NUREG-0925, June 1982. Para. 2.3.5.

9.0 Cost-Benefit Analysis

9.1 Introduction

This section has been prepared to meet the requirements established under NUREG-1569, and includes a description of the economic benefits of the proposed Dewey-Burdock Project. For the most part, benefit and cost estimates have been quantified; however, some potential environmental impacts cannot be reliably quantified and the benefit and cost estimates have been analyzed using qualitative or non-monetary terms.

The following economic analyses were created using IMPLAN (IMpact analysis for PLANning), an industry standard software used to measure the impacts due to a change in economic activity on a regional or local economy. IMPLAN was originally developed by the United Stated Department of Agriculture (USDA) Forest Service in cooperation with the Federal Emergency Management Agency (FEMA) to estimate the economic effects of proposed resource outputs on local communities. Since 1988, the Minnesota IMPLAN Group, Inc. (MIG) has managed IMPLAN for public users.

The results of the cost-benefit analysis (CBA) presented in this section establishes that the proposed project is a cost-effective project and will provide a positive economic benefit to the 50 km radius impact area and the State of South Dakota.

9.2 Alternatives and Assumptions

CBA is a standard analytical tool used to determine whether the present cost of a project will result in sufficient benefits to justify investment in a capital intensive project (Zerbe and Bellas 2006). To adequately evaluate the economic impacts of any project, the CBA needs to define the alternatives being considered and the underlying assumptions including qualities of goods, labor costs, market conditions and discount rates used to compute net present value, as well as establish the scope of impacts and non-monetary impacts.

9.2.1 Identification of Alternatives

This CBA evaluates the benefits and costs of the proposed project resulting from its future operation in Custer and Fall River counties, South Dakota. The analysis also includes a comparison of the proposed project to the no action alternative.

9.2.1.1 No Action Alternative

Under this alternative, the proposed project would not be constructed as planned. There would be no impacts to the existing environment including land and water resources at the proposed site in Fall River and Custer Counties. In addition, there would be no change to the existing underlying socioeconomic and demographic trends within the impact analysis area as positive economic benefits to local communities and the State of South Dakota would not be realized.

9.2.1.2 Proposed Action

The proposed action includes the construction and operation of a uranium in situ leach (ISL) facility. The ISL facility will utilize gaseous oxygen and carbon dioxide that are injected into the ore-body within the Inyan Kara Formation to recover the uranium which is then pumped to the surface where it is extracted and processed into the final (yellowcake) product. This proposed action involves limited surface disturbance, negligible radiological impacts with insignificant changes in the overall ground water quality at the proposed project site.

9.2.2 Key Assumptions

Key assumptions involved in the cost and benefits of the proposed project include: (1) the operating life of the proposed project; (2) the discount rate; (3) the scope of the potential impacts; and (4) non-monetary impacts. These assumptions are described in more detail below.

9.2.2.1 Operating Life of the Project

The proposed project is considered as a single unit of analysis including the sequentially developed well fields, a CPP and other ancillary facilities. For this analysis, the total operating/production life of the proposed project is assumed to be 7 years. There are three phases of operation which will be analyzed as separate units with distinct costs and benefits associated with each:

- Two years of site development and facility construction
- Seven years of well fields and CPP operations – includes continued well field construction and initiation of restoration
- Seven years of the site reclamation ground water restoration and decommissioning of well fields and ancillary facilities

9.2.2.2 Discount Rate

A cost-benefit analysis attempts to compare all applicable cost and benefits to the present value. Determining the net-present value (NPV) is calculated using a discount rate that allows for the comparison of the present value of future expenditures and allows all relevant future cost and benefits to be compared in present-value terms. A discount rate of 7.0 percent has been used for this present-value calculation as referenced in Circular A-94 from the United States Office of Management and Budget (OMB 1992). Circular A-94 was revised in 1992 based on extensive review and public comment and currently reflects the best available guidance on standardized measures of costs and benefits. This rate approximates the marginal pre-tax rate of return on an average investment in the private sector in recent years.

9.2.2.3 Scope of Impact

An important step in any cost-benefit analysis is establishing a viable scope of impact and establishing who will be affected by the proposed project (Zerbe and Bellas 2006). This analysis has been limited to the proposed project's direct zone of influence that is defined as the area within which the proposed project's impacts and benefits are reasonably anticipated to be concentrated, including the population areas most likely to contribute to the proposed project's local workforce and to provide ongoing sources of supplies and commodities during construction and operations.

The direct zone of influence required under NUREG-1569 for the proposed project's cost-benefit analysis includes a radius of 80 km (50 miles) from the center of the PAA and includes the townships, towns, and unincorporated areas within the two South Dakota counties surrounding the proposed project, Custer and Fall River. Approximately 1 mile (1.6 km) of the proposed project's western border follows the Wyoming/South Dakota state line south of Dewey, South Dakota. Therefore, the Wyoming locations of Newcastle and Osage[1] in Weston County are also included in the proposed project's direct zone of influence, but because the proposed project is located entirely within Custer and Fall River counties this cost-benefit analysis evaluates the proposed project's economic impact only within these two counties and the South Dakota taxes that will be levied. These locations are considered close enough to reasonably supply workers or supplies to the proposed project on a regular basis. No areas of appreciable population size were

[1] Osage is not an incorporated town but is defined as a "CDP" or census-designated place by the USCB in partnership with State agencies. CDPs are areas of significant population outside of any incorporated municipality and that are locally identified by a name.

located within this radius (80 km) from the proposed project in other Wyoming counties or to the south in Nebraska.

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

9.2.2.4 Non-monetary Impacts

A conventional CBA uses monetary values to compare goods and services derived from a project or program. The value of goods and services represent their relative importance. If the project's total value of the benefits is greater than the total value of the costs, then it is beneficial. While many inputs in the project CBA are goods and services that are traded in markets at established and well-known prices such as, skilled labor, construction material, and gasoline, other inputs are not directly traded and are more difficult to value (Zerbe and Bellas 2006). These inputs such as, changes to land or water resources, or aesthetic impacts have been assigned a qualitative value based on the best available information.

9.3 Economic Benefits of Project Construction and Operation

This section evaluates the potential economic impacts of construction and operation-related activities over the life of the proposed project. Economic benefits created from the proposed project include the number of jobs created and local and state tax revenues generated and other activities that have the potential to favorably affect the local economy.

This analysis uses IMPLAN as previously described to calculate the potential economic impacts to Custer and Fall River Counties. IMPLAN can tailor the input-output models according to specific regional or community data and the program can analyze the impacts from more than 500 different types of industries for counties throughout the United States. In order to analyze the impacts of the proposed project on the local economies affected, the proposed project's industry classification has been identified as mining and construction. The model also requires labor and capital expenditures as inputs in order to evaluate the potential economic impacts of the proposed project. The outputs calculated are the potential direct, indirect and induced employment impacts and tax revenues generated.

The surrounding counties of Custer and Fall River, South Dakota were analyzed using the two industry sectors most closely associated with the stages of development to of the proposed project: construction (IMPLAN code 41) and support activities for mining (IMPLAN code 29). IMPLAN does not have a specific uranium mining sector associated with Custer and Fall River counties, so all tax revenue estimates are considered as an approximation given that ad valorem and severance taxes will likely differ for different mining sectors.

9.3.1 IMPLAN Input Data

For this analysis the initiation of the construction stage of the proposed project assumes a start date of 2009 continuing through 2010. Table 9.3-1 shows the input data for construction, operation and reclamation expenditures over the life of the proposed project. The total estimated number of construction workers directly involved in construction is 86. The total non-payroll capital construction expenditures are estimated at $45.8 million per year and $21.2 million per year for operation expenditures and $2.0 million per year for reclamation expenditures.

Upon completion of the well fields and CPP, the operation will employ approximately 84 full-time employees over the following 7 year period and approximately 18 employees during the final 7 years of restoration and reclamation. It is likely that many of these employees will come from Custer and Fall River counties.

Table 9.3-1: Input Data for the Project

Activities	IMPLAN Code	Per Year		
		Year 1–Year 2	Year 3–Year 10	Year 11-Year 18
Construction Expenditures				
Non-payroll	41	$45.8 M	N/A	N/A
Payroll	41	86 Workers $3.5 M	N/A	N/A
Operation Expenditures				
Non-payroll	29	N/A	$21.2 M	$ 2.0 M
Payroll	29	N/A	84 Workers $5.6 M	18 Workers $1.0 M

9.3.2 Employment Benefits

Using the Input Data from Table 9.3-1, IMPLAN can generate the potential employment-related effects of the proposed project. IMPLAN defines employment as total wage and salary employees, including self-employed jobs that are related to the proposed project. It also includes both full-time and part-time workers and is measured in annual average jobs.

Table 9.3-2 shows the potential direct, indirect and induced effects on Custer and Fall River Counties' employment. The direct employment effects refer to the employment directly generated by the proposed project. For the initial construction phase in years one to two, the model estimated the potential for an additional 171 non-payroll (indirect and induced) workers that could be hired in Custer and Fall River Counties based on the 86 payroll workers engaged directly in construction activities and the $45.8 million in non-payroll capital expenditures incurred by the proposed project per year.

Table 9.3-2: Employment Effects of the Project in Custer and Fall River Counties

	Employment			
Years	**Direct**	**Indirect**	**Induced**	**Total**
1 - 2	86	45	126	257
3 - 10	84	36	35	155
11 - 18	18	3	3	24

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

These results indicate that the proposed project has the potential to create a total of 257 (including 86 Powertech (USA) employees) jobs during the construction stage and a total of 155 (including 84 Powertech (USA) employees) jobs during the operation stage and 23 (including 18 Powertech (USA) employees) jobs during the reclamation stage of the proposed project. The economic impacts of the proposed project will not limited to Custer and Fall River Counties, but will likely benefit the surrounding Counties of Weston, Niobrara, and Pennington because of increased commerce and capital exchange within the region.

9.3.3 State and Local Tax Revenue Benefits

In addition to the employment benefits of the proposed project, IMPLAN can calculate the expected State and Local taxes generated over the life of the proposed project. In order to remain consistent with the scope of impact, Federal taxes are not included in this analysis. The

results presented in Table 9.3-3 are standardized to 2008 dollar equivalents using the OMB recommended real discount rate of 7.0 percent.

Potential state and local tax revenue associated with the proposed project are presented in Table 9.3-3. Only indirect business taxes, which include excise taxes, property taxes, fees, licenses, and sales taxes that stem directly from the construction and operation of the proposed project and paid by Powertech (USA) are presented instead of the tax revenue generated from employee or employer social insurance taxes, which represent only a transfer of wealth rather than a net economic gain when compared to the no action alternative.

As shown in Table 9.3-3, the results from the IMPLAN analysis indicate that the construction, operation and reclamation stages of the proposed project are expected to generate a net present value of approximately $13.54 million in total business tax revenue over the life of the proposed project. The total enterprise (corporate) tax was not analyzed because South Dakota does not levy a Corporate Income tax.

Table 9.3-3: IMPLAN Projections of State and Local Tax Revenue

	Construction 2 years	**Operation 7 years**	**Reclamation 7 years**	**Total**
Indirect Business Tax Revenue	**Net Present Value ($)***			
Motor Vehicle License (per annum)	$10,800	$6,107	$552	
Other Taxes (per annum)	$51,351	$29,037	$2,627	
Property Tax[1] (per annum)	$334,485	$334,485	$334,485	
State/Local Non Taxes (per annum)	$28,602	$16,173	$1,463	
Sales Tax[2] (per annum)	$1,374,000	$636,000	$60,000	
Total Indirect Business Taxes per Year	$1,799,238	$1,021,802	$399,127	
Total Indirect Business Taxes	$3,598,476	$7,152,614	$2,793,889	**$13,544,979**

*2008 Dollar Equivalents

[1]Property Tax was calculated using the value generated by the IMPLAN model for construction, $334,485.

[2]Sales Tax was calculated by applying 3% to the total non-payroll expenditures

In addition to the business tax revenues, the State of South Dakota, Special Tax Division of the Department of Revenue and Regulation levies a uranium severance tax of 4.5 percent as well as 0.24 percent conservation tax on the taxable value of any energy mineral produced from mining operations (South Dakota Department of Revenue and Regulations – Special Tax Division 2008). Current resource estimates for the proposed project are 7.6 million lbs. (43-101 compliant). A total reserve estimate has not been included because it is still incomplete. Assuming that the identified 7.6 million lbs were sold at current market prices of approximately $60 per pound, the severance tax would yield approximately $20,520,000 in net economic

benefits over the life of the operation, 50 percent of which would be collected by the counties, and an additional $1,094,400 for the conservation tax. The total taxes generated over the lifetime of the proposed project, including indirect business taxes, are estimated to be approximately $35.1 million.

9.3.4 State and Local Value Added Benefits

IMPLAN was used to calculate the value added benefits to Custer and Fall River Counties. Value added is a measure of wealth created by an economy, in other words, as an industry buys goods and services and remanufactures those goods to create a product of greater value, this increase in value represents the value added. The IMPLAN model calculates the value added based on four components, employee compensation, proprietor income, other property income and indirect business tax. Employee compensation is wage and salary payments as well as benefits. Proprietary income consists of payments received by self-employed individuals as income. Other property type income consists of payments from interest, rents, royalties, dividends, and profits. Indirect business taxes consist primarily of excise and sales taxes paid by individuals to businesses. As shown in Table 9.3-4, the results from the IMPLAN analysis indicate that the construction, operation and reclamation stages of the proposed project are expected to generate approximately $186.7 million in value added benefits over the life of the proposed project.

Table 9.3-4: Value Added Benefits

	Construction 2 years	**Operation 7 years**	**Reclamation 7 years**	
South Dakota/Fall River & Custer Counties				**Total**
Value Added (per annum)	$39,091,679	$14,135,859	$1,366,119	
Total	$78,183,358	$98,951,013	$9,562,833	$186,697,204

9.3.5 Benefits of Environmental Research and Monitoring

Due to the remoteness and low population of the PAA, the ongoing environmental baseline studies and monitoring have greatly increased the information available on area's natural resources. Required operational monitoring as presented in Section 5.0 will continue to provide beneficial scientific data about the area.

9.4 External Costs of Project Construction and Operation

This section of the BC analysis evaluates the external costs of the proposed project. Both short-term and long-term external costs are also identified and described for people living in the surrounding communities not directly involved in the proposed project.

9.4.1 Short Term External Costs

9.4.1.1 Housing Shortages

Because of the proposed project's close proximity to the more populated communities of Custer City and Hot Springs, South Dakota and Newcastle, Wyoming with a combined population greater than 9,000 people, it can be assumed that much of the workforce would come from these localities. The remaining workforce would likely relocate from the surrounding area (e.g., South Dakota, Nebraska and Wyoming). The IMPLAN model results show that during the two year constructional stage, the proposed project has the potential to sustain the creation of 257 new jobs for two years. During the following 7 year operation stage the proposed project has the potential to sustain the creation 155 jobs for seven years, and 23 jobs over the final seven years.

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

9.4.1.2 Impacts on Schools and Other Public Services

There are several schools located within Custer and Fall River Counties. The Custer School District includes: Custer Elementary, Hermosa Elementary, Fairburn Elementary, Spring Creek Elementary, Custer Middle, and Custer High School. Total enrollment for the Custer School

District is 991 students with a student to teacher ratio of 12.1 to 1. The Hot Springs School District includes: Hot Springs Elementary, Hot Springs Middle and Hot Springs High School. Total enrollment for the Hot Springs School District is 873 students with a student to teacher ratio of 12.9 to 1. The Edgemont School District includes: Edgemont Elementary, Edgemont Junior High and Edgemont High School with a total enrollment of 138 students and a student to teacher ratio of 8.8 to 1.

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

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

9.4.1.3 Impacts on Noise and Congestion

There are only a few residences in the vicinity of the proposed project. Most of the land in the surrounding a 2 km radius of the proposed project is devoted to rangeland. Other land uses include grazing, crop land, hunting and wildlife habitat. As a result of the low population density of the area surrounding the proposed project site, the anticipated limited use of large machinery and vehicles and the infrequent movement of transport vehicles to and from the proposed project site, no significant noise or congestion impacts are anticipated within the surrounding 2 km area during operations. There will be some increased traffic, noise and dust on the county road between the site and Edgemont during construction activities. However, these impacts will be of short duration.

9.4.2 Long Term External Costs

9.4.2.1 Impairment of Recreational and Aesthetic Values

While several opportunities for recreational activities exist in the Custer and Fall River counties surrounding the proposed project and within the proposed project's surrounding 2 km area, the current recreational use is limited to deer, elk, and antelope hunting. Prior to commencement of operations, Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable. However, this activity will not be permanent as hunting will return following reclamation of the site.

Within a 50-mile radius of the proposed project, recreational areas include Buffalo Gap National Grassland, the George S. Mickelson Trail, the Black Hills National Forest, Jewel Cave National Monument, Angostura State Recreation Area, Custer State Park, Mount Rushmore National Memorial and Wind Cave National Park.

While the proposed project is geographically located within 50 miles of several federal and state recreational areas, it will have only a minor affect on the regional recreational and aesthetic values because of its remote location and its limited access to large or highly traveled state roads or federal highways that service these recreational areas. Also, the proposed project will not impair the existing aesthetic values of the area due to limited surface land disturbance and the construction of minimal structures that will not be visible from any major highway or scenic vantage point in the area.

9.4.2.2 Land Disturbance

The land that encompasses the PAA has been historically used for cattle grazing and open-pit uranium mining operations. Therefore, the proposed project site has been previously disturbed and impacted from agricultural and mining activities.

The in situ leach (well field) method of uranium mining minimizes land surface disturbance in comparison to conventional surface or underground mining and milling methods that cover large areas and generate waste rock and mill tailings. In addition, the land surface disturbance associated with constructing ISL well fields and access roads will only be short-term as concurrent reclamation with native vegetation will occur throughout the life of the proposed project. Short-term surface disturbance impacts could result from the construction and operation of the CPP, surface impoundments and irrigated land until final reclamation and closure of these facilities is completed.

A Level III cultural resources evaluation and report have been prepared (Appendix 2.4-A) that includes a survey of archaeological sites within the entire permit boundary. Sites that may require additional data evaluation or recovery will be avoided as well field development progresses. More detail is provided in Section 2.4 on cultural resources within the PAA.

9.4.2.3 Habitat Disturbance

The PAA has historically been used for cattle rangeland and has been the site of mining and exploration projects since the 1950's. There are no anticipated adverse impacts or irreversible loss of surface vegetation or wildlife habitat relative to existing conditions as a result of proposed project operations. All of the disturbed land will be reclaimed after the proposed project is decommissioned and will become available for its pre-operational uses. Potential environmental impacts to vegetation and wildlife are discussed in Section 7.2.7.

9.4.3 Groundwater Impacts

Operational controls during production and groundwater restoration will assure that leach fluids are contained and will not impact nearby underground sources of drinking water. The use of groundwater supply for operations will be a temporary commitment of water resources and Powertech (USA) expects that the proposed groundwater restoration techniques will be successful at returning the production zones at the proposed project site to restoration target values, which will help protect underground sources of drinking water and allow the aquifers impacted to return to their pre-operational class of use. Potential impacts to groundwater resources are discussed in Section 7.2.5.

9.4.4 Radiological Impacts

The potential radiological impacts due to the proposed project during operation are small (as discussed in Section 7.3). The decommissioning of the Proposed project site and disposal of radioactive material will follow all applicable NRC requirements and/or license conditions and will be transported off site to an NRC or Agreement State licensed 11e.(2) disposal facility. The radiological effects including estimated exposures from the water and air pathways are discussed in Section 7.3.

9.5 Cost-Benefit Summary

The most significant benefits of the proposed project are its potential to sustain the creation of 257 new jobs during construction, 155 jobs during operation, and 23 jobs during reclamation, all

of which include the direct, indirect and induced effects on the local economies. In addition, an estimated $91.6 million during construction will be spent on non-payroll expenditures, $148.4 million during operation and 14.0 million during reclamation; and approximately $35.1 million in state and local tax revenue and $186.7 million in value added benefits are expected to be generated over the life of the proposed project (Table 9.5-1) as a result of the proposed project.

Table 9.5-1 summarizes the associated short-term and long-term cost of the proposed project. Impacts to the regional housing market should be minimal because of the large percentage of local workers, impacts to schools and public facilities should be negligible because of their present ability to absorb any associated regional influx, and the impact of noise and additional traffic presents little or no change compared to the no action alternative. Due to the remote location of the proposed project and minimal surface disturbance, impacts to recreational activities and aesthetic values within the area should be negligible.

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

Table 9.5-1: Summary of Benefits and Costs for the Project

Benefits	Costs
Value Added $186,697,204 **Tax Revenue** $35.1 million **Potential to create temporary and permanent jobs** 257 jobs over two years (2009-2010) during construction 155 jobs over seven years (2011-2017) during operation 23 jobs over seven years (2018-2024) during reclamation **Increased knowledge of the local environment and natural resources**	**Housing Impacts** Little or no change **Schools and Public Facilities** Negligible **Noise and Congestion** None **Impairment of Recreation and Aesthetic Values** Negligible **Land Disturbance** Minor **Groundwater Impacts** Controlled through mitigation **Radiological Impacts** Controlled through mitigation

9.6 References

IMPLAN 2004, "*IMPLAN Professional Version 2.0 Manual Third Edition*", Minnesota IMPLAN Group, Inc., February.

U.S. Office of Management and Budget (OMB), 1992, Circular No. A-94, "*Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*".

Zerbe, R. O. and A. S. Bellas 2006, "*A Primer for Benefit-Cost Analysis*". Northampton, MA: Edward Elgar.

10.0 Environmental Approvals and Conclusions

In order for the Dewey-Burdock Project to operate, permits and approvals from numerous Federal and State agencies will be required. Section 10.1 identifies the issuing agencies, a description of the type of permit, license or approvals needed, and the current status of securing these approvals.

10.1 Applicable Regulatory Requirements, Permits, and Required Consultations

Necessary environmental approvals from Federal and State Agencies required for the proposed project are listed in Table 10.1-1. The NRC licensing process for a source materials license represents the longest lead-time approval. The majority of the remaining approvals are in-progress or will be initiated with in the next year. All necessary approvals must be secured prior to commencement of commercial production at the site.

Table 10.1-1: Permits and Licenses for the Dewey-Burdock Project

Issuing Agency	Description	Status
South Dakota Department of Environment and Natural Resources Joe Foss Building 523 E Capitol Pierre, SD 57501	Uranium Exploration Permit	Submitted
	Temporary Water Right for Testing	Submitted
	Temporary Discharge Permit for Testing	Submitted
	Scenic and Unique Lands Designation	Submitted
	Large Scale Mine Permit	Pending
	Water Appropriation Permit	Pending
	Air Quality Permit	Pending
	Groundwater Discharge Permit	Pending
	NPDES Water Discharge Permit	Pending
US Nuclear Regulatory Commission Washington, DC 20555	Source Materials License	Application Submitted herein
US EPA Region 8 8OC-EISC 1595 Wynkoop St Denver, CO 80202-1129	Aquifer Exemption	Pending
	Class III Underground Injection Control Permit	Pending
Custer County 420 Mount Rushmore Road Custer, SD 57730-1934	Building Permits	Pending
Fall River County County Courthouse Hot Springs, SD 57747-1309	Building Permits	Pending

10.2 Environmental Consultation

Over the course of license application preparation, consultations were conducted with several State and Federal agencies as listed in Table 10.2-1 below.

Table 10.2-1: State and Federal Agencies Contact Information

State Agency	Department	Location
South Dakota Game Fish and Parks	Wildlife	523 East Capitol Avenue Pierre, SD 57501
South Dakota State Archaeologist	Archaeologist	P.O. Box 1257 Rapid City, SD 57709-1257
SD Dept of Environment and Natural Resources	Minerals and Mining Program	523 E Capitol Ave Pierre, SD 57501
Federal Agency		
U.S. Geological Survey	Dakota Mapping Partnership Office	1608 Mountain View Road Rapid City, SD 57702
U.S. Army Corps of Engineers	Resource Management	441 G. Street, NM Washington, DC 20314-1000
U.S. Forest Service, South Dakota	Supervisor's Office in Custer, SD	25041 North US Highway 16 Custer, SD 57730-7239
Natural Resources Conservation Service	Pierre Service Center	1717 N Lincoln Ave Pierre, SD 57501-2398
U.S. Nuclear Regulatory Commission	Uranium Recovery Licensing Branch	Washington, DC 20555-0001
US EPA Region 8	8P-W-GW	1595 Wynkoop Street Denver, CO 80202-1129