Powertech (USA) Inc.

TABLE OF CONTENTS (Continued)

4.1.1 Streams ... 98

4.1.1.1 Stream Sampling ... 98

4.1.1.2 Stream Sampling Results ... 101

4.1.2 Impoundments ... 104

4.1.2.1 Impoundment Sampling ... 104

4.1.2.2 Impoundment Sampling Results ... 105

4.2 Groundwater Quality ... 108

4.2.1 Groundwater Sampling ... 108

4.2.2 Groundwater Sampling Results ... 111

4.2.3 Groundwater Classification ... 114

5.0 DESCRIPTION OF DISCHARGE FACILITY ... 116

5.1 Dewey Land Application System Design ... 116

5.2 Burdock Land Application System Design ... 118

5.3 Pond Design ... 120

5.4 Catchment Areas ... 120a

5.5 Irrigated Crops ... 121

5.6 Land Application System Operation ... 121

5.7 Hydrologic Land Application and Pond Simulations ... 122

5.7.1 SPAW Model Description ... 122

5.7.2 Model Input Parameters ... 122

5.7.2.1 Meteorological Parameters ... 122

5.7.2.1.1 Precipitation ... 123

5.7.2.1.2 Potential Evapotranspiration ... 123

5.7.2.2 Material Properties ... 124

5.7.3 Modeling Approach ... 124

5.7.4 Model Results ... 126

5.8 Land Application Water Properties ... 132

6.0 MONITORING PLAN ... 137

6.1 Groundwater ... 137

6.1.1 Alluvial Groundwater Monitoring ... 137

6.1.1.1 Alluvial Monitor Wells ... 137

6.1.1.2 Sample Collection and Analysis Methods ... 141

TABLE OF CONTENTS (Continued)

Figure 3.1-18: Heating Degree Days for Regional Sites 33
Figure 3.1-19: Degree Days for Newcastle NWS Site 33
Figure 3.1-20: Average Monthly Accumulated Evapotranspiration for Oral, South Dakota 34
Figure 3.1-21: Average Monthly Evaporation for Casper, Wyoming 34
Figure 3.1-22: Average Temperature by Month from the Project Meteorological Site 37
Figure 3.1-23: Diurnal Average Temperature for the Project Meteorological Site by Season 37
Figure 3.1-24: Probability Plot of Average Temperature from the Project Meteorological Site 38
Figure 3.1-25: First and Second Quarter Wind Roses 40
Figure 3.1-26: Third and Fourth Quarter Wind Roses 41
Figure 3.1-27: Annual Wind Rose 42
Figure 3.1-28: Dewey-Burdock Monthly Wind Speeds 43
Figure 3.1-29: Diurnal Relative Humidity by Season from Project Meteorological Site 45
Figure 3.1-30: Monthly Precipitation from the Project Meteorological Site 45
Figure 3.1-31: Estimated Evapotranspiration Calculated Using Weather Data Collected at the Project Meteorological Site 46
Figure 3.2-1: Soil Map for Proposed Dewey Land Application Area 50
Figure 3.2-2: Soil Map for Proposed Burdock Land Application Area 51
Figure 3.3-1: Vegetation Map for Proposed Dewey Land Application Area 60
Figure 3.3-2: Vegetation Map for Proposed Burdock Land Application Area 61
Figure 3.5-1: Residences and Drinking Water Wells in Relation to Land Application Areas 67
Figure 3.6-1: Geologic Map of the Black Hills 69
Figure 3.6-2: Stratigraphic Column of the Black Hills 71
Figure 3.6-3: Site Surface Geology 72
Figure 3.7-1: Regional Map of the Beaver Creek Basin and Pass Creek Subbasin 78
Figure 3.7-2: Surface Water Impoundments within 1 Mile of the Dewey POP Zone 80
Figure 3.7-3: Surface Water Impoundments within 1 Mile of the Burdock POP Zone 81

LIST OF PLATES

Plate 3.2-1 Soil Map

Plate 3.3-1 Vegetation Communities Map

Plate 3.6-1 Structure Map of the Fall River Formation

Plate 3.6-2 Isopach of the Fall River Formation

Plate 3.6-3 Isopach of the Graneros Group

Plate 3.6-4 Isopach of the Alluvium

Plate 3.6-5 Cross Section A-A'

Plate 3.6-6 Cross Section B-B'

Plate 3.6-7 Cross Section C-C'

Plate 3.6-8 Cross Section D-D'

Plate 3.6-9 Cross Section E-E'

Plate 3.6-10 Pass Creek Alluvium Cross Sections

Plate 5.4-1 Conceptual Catchment Area Design, Dewey Land Application Area

Plate 5.4-2 Conceptual Catchment Area Design, Burdock Land Application Area

marine shale with minor amounts of siltstone, fine grained sandstone, and a few thin beds of bentonite. Dark-gray to purple and black iron and manganese concretionary zones are common within the shale. When present the Newcastle Sandstone is stratigraphically located between the Skull Creek Shale and the Mowry Shale. Drilling has encountered no Newcastle Sandstone on the surface or in the subsurface within the Dewey-Burdock project area.

Belle Fourche Shale - The uppermost unit of the Graneros Group is the Belle Fourche Shale. This 300-foot unit consists of thin-bedded gray to black soft shale, containing black-reddish brown ironstone concretions, which are particularly abundant in the basal 20-30 feet. There is also bentonite production from the lower part of the Belle Fourche Shale.

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

Alluvium - The most recent sedimentary units are the Quaternary age alluvium deposits, which are present in the major drainages and their tributaries. The alluvium consists of silt, clay, sand and gravel. An isopach of the alluvium is presented as Plate 3.6-3. Cross sections of the Pass Creek alluvium are presented on Plate 3.6-10.

Powertech (USA) completed an alluvial geotechnical drilling program in May 2011 to further characterize the alluvium within the project area. Nineteen borings were drilled into the alluvium along Beaver Creek and Pass Creek, many of which were dry. Alluvial drilling logs indicating water levels (where present) are provided in Appendix 3.6-A. The alluvium in the Pass Creek drainage is up to 50 feet thick; in the Beaver Creek drainage, the alluvium is up to 30 feet thick. Only the bottom 0 to 15 feet of the alluvium typically contains gravel, and this is typically a mixture of silt, clay and sand with scattered gravel. The top of the alluvium contains a mixture of silt, clay and sand and may be better described as colluvium.

3.7 Hydrology

3.7.1 Surface Water

3.7.1.1 Regional Surface Water Hydrology

The project area is on the southwest flank of the Black Hills. The area includes two physiographic divisions that are characterized as the Black Hills and the Great Plains Divisions. The Black Hills Division generally consists of steep formations of metamorphosed and intensely

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a geonet, which will provide a physical separation and allow any fluid to flow between the two liners. A minimum grade of 2 percent will be maintained across the bottom of the pond toward a leak detection sump. Any potential leakage from the primary liner will be contained by the secondary liner and collected in the leak detection sump. The sump will be routinely monitored for the presence of fluid as described below. Should a leak occur, the pond will be removed from service and dewatered by transferring the contents to a spare pond.

Routine inspections for all ponds will be conducted in accordance with NRC license requirements as discussed in Section 10. In addition, routine inspections for ponds with leak detection systems will include daily checks for water accumulation in leak detection systems and monthly inspections of the functionality of leak detection systems.

5.4 Catchment Areas

Runoff from significant precipitation events or snowmelt on the land application areas will be conveyed to catchment areas within or adjacent to the pivot areas and allowed to evaporate or infiltrate. The minimum collection area will be 35 acres at each of the Dewey and Burdock sites, and the capacity will be sufficient to contain the estimated 100-year runoff event from each center pivot area. The application rate will be maintained at an agronomic rate that will prevent water from accumulating in the catchment areas during normal operation. The application rate will be adjusted as necessary including temporary shutdown if needed to prevent excessive ponding in the catchment areas. Following is a description of the conceptual catchment area design and operating plan. Prior to operation of the land application systems, Powertech (USA) will submit final designs of the catchment areas as indicated below.

Conceptual Catchment Area Design

Plates 5.4-1 and 5.4-2 present the conceptual designs of the Dewey and Burdock catchment areas, respectively. The final designs may vary from those shown on the plates but will include a minimum surface area of 35 acres at each of the Dewey and Burdock sites and sufficient capacity to contain the estimated 100-year, 24-hour runoff event from all center pivot areas and contributing drainage areas.

The conceptual designs include multiple catchment areas for each of the Dewey and Burdock sites. Earthen catchment berms typically will be constructed at the downgradient edges of the pivot areas or in common locations downgradient of multiple pivot areas. Catchment berms typically will be less than 6 feet high or will have an impounding capacity (excluding incised capacity) less than or equal to 15 acre-feet. Therefore, they are anticipated to be classified as "barriers" according to ARSD 74:02:08:01(7) and not require consideration of dam safety requirements in ARSD 74:02:08. Only one of the conceptual designs includes a capacity greater than 15 acre-feet and berm height greater than 6 feet (B-15 in the Burdock area). In this case the catchment area will be incised sufficiently such that the impounding capacity will be 15 acre-feet or less.

For each catchment area, the runoff volume resulting from the 100-year, 24-hour precipitation event was calculated. The 100-year, 24-hour general storm runoff was estimated using the Natural Resource Conservation Service triangular hydrograph method, a parametric method of estimating flood peaks and volumes from drainage area, relief, soil type, vegetative cover and stream length. The precipitation value (4.8 inches) for the 100-year, 24-hour storm event was obtained from the national depth-duration frequency map. This is the same value used for the flood analysis of Pass Creek and ephemeral tributaries within the project area described in Section 3.7.1.3.

Summary tables are presented on each plate describing the individual and combined area and volume of the conceptual catchment areas and the estimated 100-year, 24-hour storm runoff volumes. In the conceptual design, the combined area is about 70 acres for each site, which is about twice the minimum area of 35 acres described in Section 5.4. The combined capacity is 141 to 167 acre-feet, which is approximately 18 to 50% more than the total estimated 100-year, 24-hour runoff volume.

In most cases, the catchment areas will have excess capacity beyond the minimum required to contain the 100-year, 24-hour runoff event. The elevation corresponding to the excess capacity volume, where applicable, is designated on each area capacity table on Plates 5.4-1 and 5.4-2. This is termed "inactive capacity" on the plates and represents the normal operating level for each catchment area. As described below, a dewatering program will be initiated if the catchment areas fill above the normal operating level.

In a few cases, two or more catchment areas will be used to contain the 100-year, 24-hour storm runoff volume from multiple drainage areas. In these cases, overflow from upgradient catchment areas will be routed to a downgradient catchment area as indicated on the plates. The overflow will be conveyed in pipelines and/or ditches sized to convey the excess runoff at non-erosive velocities during the 100-year, 24-hour runoff event. In one or more cases berms with catchment ditches will be constructed at the edges of pivot areas to convey the runoff within the pivot areas to the catchment areas (i.e., the pivot area associated with Catchment D-13 in the Dewey land application area).

Typical cross sections are provided on the plates traversing multiple pivot and catchment areas. The plates also depict the relationship between the conceptual catchment area designs and the general catchment area boundaries depicted on other figures and plates in this application (e.g., Figure 2.3-2 and Plates 3.6-5 through 3.6-10). The conceptual designs are within the general boundaries. The actual extents of the catchment areas also will be within or very close to the general catchment area boundaries depicted in this application. The actual extents will be determined during final design as described below.

Conceptual Catchment Area Operating Plan

Powertech (USA) will operate the catchment areas to maintain adequate freeboard capacity for the estimated 100-year, 24-hour storm runoff. This will be accomplished by marking the elevation of the normal operating level in each catchment area, or, in the case of multiple catchment areas operated in series, marking the elevation of the normal operating level in the most downgradient catchment area. The normal operating level will be delineated with a clearly visible marker such as a post. Each catchment area will be routinely monitored, including after significant precipitation events.

The land application water will be applied at an agronomic rate to prevent runoff into the catchment areas except during significant precipitation or snowmelt events. If a catchment area fills above the normal operating level, a dewatering program will be initiated. The catchment area will be dewatered through pumping or gravity discharge. The excess water will be conveyed to another catchment area with excess operating capacity, pumped to the storage ponds, or pumped to a land application pivot area (primary or standby area).

The conceptual catchment area design includes sufficient excess capacity such that dewatering would not be required frequently. This is demonstrated by the calculated 2-year, 24-hour runoff volumes listed on the summary tables on Plates 5.4-1 and 5.4-2. These runoff volume estimates are provided to illustrate how the catchment areas would be operated during a more frequent precipitation event. In each case, the total 2-year, 24-hour runoff volume is approximately equal to or less than the excess capacity, which is calculated as the total catchment capacity less the designated freeboard volume for the 100-year, 24-hour storm event. In the Dewey area, the conceptual catchment capacity is approximately 167 acre-feet and the 100-year, 24-hour runoff volume is approximately 111 acre-feet. The excess capacity is therefore about 56 acre-feet, or about 300% of the 2-year, 24-hour runoff volume of about 18 acre-feet. In the Burdock area, the excess capacity is about 22 acre-feet, which is approximately equal to the 2-year, 24-hour runoff volume of 23 acre-feet. This shows that the frequency at which the normal operating level would be exceeded for the combined catchment areas would typically be less than or equal to every 2 years. In this case the excess water would be pumped to a pivot area (likely a standby pivot area) or to the storage ponds. The final operating plan described below will include standard operating procedures to ensure that there will be adequate storage pond excess capacity or standby pivot areas such that dewatering could be accomplished in a reasonable amount of time.

The calculation of 2-year, 24-hour runoff volumes for the catchment areas also demonstrates that the quantity of water evaporating or infiltrating in the catchment areas will be much smaller than the quantity of water applied to the land application areas. As described in Tables 5.1-1 and 5.2-1, the design average annual application volume is 500 acre-feet for each land application system. By comparison, the calculated 2-year, 24-hour runoff volume for the catchment areas is about 18 to 23 acre-feet. This shows that the volume of runoff captured during a storm event that is predicted to occur every other year will only be about 4 to 5% of the design land application volume each year. This supports the conclusion that the catchment areas will have minimal potential groundwater impacts compared to the land application areas.

Final Design and Operation and Maintenance Plan

Prior to operating the land application systems, Powertech (USA) will provide the following information to DENR for review and approval:

1) Final catchment area designs, including hydrologic calculations for the 100-year, 24-hour runoff volumes, catchment area capacities and areas, normal operating levels, berm dimensions, overflow hydraulic designs, and dewatering systems;
2) As-constructed drawings showing the surveyed staged storage capacity, berm dimensions and elevations of the normal operating levels (which will be identified in the field by highly visible markers with the location shown on the as-constructed drawings);
3) Demonstration that water rights have been obtained for all catchment areas, if applicable;
4) Demonstration of catchment area compliance with Safety of Dams regulations in ARSD 74:02:08; and
5) An operation and maintenance (O&M) plan for the Dewey and Burdock sites that includes:
    a. Inspection procedures, including operating level monitoring frequency and berm inspection frequency;
    b. An operation plan describing the overflow and dewatering procedures; and
    c. A dewatering plan describing how each catchment area will be dewatered in the event that the water level exceeds the normal operating level.

5.5 Irrigated Crops

Irrigated crops may include one or more of the following: native vegetation (primarily warm season perennial grasses, cool season perennial grasses, and perennial shrubs), alfalfa, or salt-tolerant wheatgrass.

5.6 Land Application System Operation

The center pivot irrigation systems will typically operate 24 hours per day during the normal frost-free season, which is approximately April through October. The land application systems will have variable operation schedules to allow for adjustments due to weather conditions and other site-specific conditions. The land application system design will allow for instantaneous shutdown of any one or more center pivots as needed. Temporary shutdowns would occur in the event of a piping leak, for maintenance activities, during significant precipitation events, due to excessive ponding in a catchment area, or due to cold temperature. The land application systems will not be used when water cannot infiltrate due to frozen ground. During times when land application will not be used, the treated liquid waste stream will be temporarily stored in ponds. As discussed in Section 5.7.4, the storage ponds will have significant surplus capacity. This will provide contingency to allow for a late spring startup or an early fall stoppage of operations. In addition, Section 5.3 describes how the central plant pond will provide additional capacity for blending of process water to keep the land application water quality relatively consistent.

The land application schedule will follow the project schedule shown in Figure 2.4-1. Land application will occur during production and restoration, the total duration of which is expected to be approximately 9.25 years. During the initial production period prior to restoration, which is expected to last approximately 1.5 to 2 years, the land application rate will be relatively low. During this phase the CPP liquid waste will be stored in the central plant pond and the land application solutions will consist almost entirely of production bleed. The average annual production bleed will be less than 100 gpm, or less than one-third the design average annual application rate of 310 gpm shown in Tables 5.1-1 and 5.2-1. The land application rate will be highest during concurrent production and restoration, which is expected to last approximately 6 years. The design application rates shown in Table 5.1-1 and 5.2-1 are based on this period of operation. The final project phase will be restoration without concurrent production. The land application rate during this relatively brief phase (approximately 0.25 year) will be slightly less application areas following cessation of land application system operation. These model results demonstrate lack of potential to impact groundwater quality from the land application systems.

8.2 Surface Water

The two primary means of avoiding potential impacts to surface water quality are protection from flooding and containment of land application solutions. Specific mitigation measures are described below.

Flood Protection

The primary means of preventing impacts from flooding is siting the land application areas to avoid the floodplains of Pass Creek, Beaver Creek, and ephemeral tributaries. Figures 8.2-1 and 8.2-2 depict the location of the proposed land application facilities in relation to the modeled 100-year floodplains for Beaver Creek, Pass Creek, and ephemeral tributaries. These figures show that nearly all of the center pivots and catchment areas will be constructed to avoid potential flooding.

In cases where flood inundation areas cannot be avoided, Powertech (USA) will implement engineering controls to prevent impacts to the land application systems from flooding. These will include constructing diversion channels and berms. These engineering controls will be permitted through the DENR Minerals and Mining Program as part of the LSM permit. Other engineering controls used to minimize potential impacts to surface water quality will include stormwater best management practices (BMPs) that will be implemented as part of a construction NPDES permit that will be required through DENR. Example stormwater BMPs that may be used to minimize potential impacts to surface water quality from construction of the land application systems include silt fence, sediment logs, and straw bale check dams.

Containment of Land Application Solutions

Powertech (USA) will provide containment for all land application solutions by constructing catchment areas around each center pivot. As described in Section 5.4, runoff from significant precipitation events or snowmelt on the land application areas will be conveyed to catchment areas within or adjacent to the pivot areas and allowed to evaporate or infiltrate. Sufficient catchment area capacity will be provided to contain the runoff from the 100-year, 24-hour storm. Powertech (USA) will monitor the catchment areas daily to ensure that there is not excessive ponding and that adequate capacity is available for containment of rainfall/runoff from the 100-year, 24-hour storm. Powertech (USA) will adjust the land application rate or dewater the catchment areas if the freeboard capacity limits are approached. The excess water will be conveyed to another catchment area with excess operating capacity, pumped to the storage ponds, or pumped to a land application pivot area.

8.3 Soil

During land application, there could be potential impacts to the soil from the buildup of salts, changes in SAR, buildup of radionuclides, buildup of metals and metalloids, and decrease in soil fertility. Mitigation of each of these potential impacts is described below.

Salinity and EC

The expected land application water quality is described in Section 5.8. With an anticipated TDS concentration of 1,000 to 5,000 mg/L, the water will pose a low to moderate risk to the growth of moderately sensitive crops such as alfalfa. Soil salinity levels will be controlled by blending the land application water in the ponds and by leaching salts below the root zone during land application. Powertech (USA) will operate the land application systems to balance the downward migration of water, which has potential alluvial groundwater impacts, with the leaching that will be used to control salt buildup in the root zone.

The anticipated SAR levels are 2 to 6, which should pose a low risk to soil infiltration rates. Should soil SAR increase and pose a risk to soil infiltration, Powertech (USA) will use amendments as necessary such as sulfur or gypsum.

Radionuclides

Since Powertech (USA) will treat the land application water to meet the 10 CFR Part 20, Appendix B, Table 2, Column 2 standards for release of radionuclides to the environment, it is unlikely that radionuclides will build up to potentially harmful levels. This will be verified through operational soil monitoring and additional surveys during decommissioning. Powertech (USA) has evaluated potential uranium chemical toxicity through various exposure pathways and determined that these concentrations should not result in chemical toxicity effects. These concentrations will be the trigger levels for operational monitoring, at which the contingency plan described below will be implemented.

During decommissioning, Powertech (USA) will conduct land cleanup in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and DENR requirements. This includes cleaning up surface soils to standards for radium-226 and natural uranium that will be established as conditions in the NRC license as protective of human health and the environment.