EPA REGION 8’S RESPONSE TO PETITION FOR REVIEW

# Attachment I

Doc 265, Draft Aquifer Exemption Record of Decision (March 3, 2017)

# U.S. EPA Region 8
# Underground Injection Control Program

## AQUIFER EXEMPTION DRAFT RECORD OF DECISION

This Draft Record of Decision provides the EPA's aquifer exemption (AE) decision, background information concerning the AE request, and the basis for the AE decision requested by Powertech (USA) Inc. for the Dewey-Burdock uranium in-situ recovery (ISR) site in Custer and Fall River Counties in South Dakota.

**Primacy Agency**: EPA Region 8 Direct Implementation Program under Section 1422 of the Safe Drinking Water Act for the State of South Dakota

**Date of AE Request**: January 2013

**Major or Minor (Substantial or Non-Substantial) Approval**: **Minor** (**Non-Substantial)**
While the action before the EPA is not a state program revision, but rather an approval of an AE in a federally-administered program, the process is treated similarly and requires the EPA to determine whether the AE approval is major or minor (i.e. substantial or non-substantial). The process is discussed in the Preamble of 49 Fed. Reg. 40098, 40108 (September 2, 1983); see also 49 Fed. Reg. 20138, 20143 (May 11, 1984). The process differs depending on whether the EPA treats the decision as a major or minor program revision. The EPA has determined this AE decision is minor, or non-substantial, because it is associated with the issuance of a site-specific UIC Class III permit action, not a state-wide programmatic change or a revision with implications for the national UIC program. The decision to treat this AE as a minor, non-substantial program revision is also consistent with the corresponding state program revision process detailed in EPA Guidance #34: *Guidance for Review and Approval of State Underground Injection Control (UIC) Programs and Revisions to Approved State Programs*. Guidance 34 explains that the determination as to whether a program revision is substantial or non-substantial is made on a case-by-case basis, and with the exception of AEs associated with certain Class I wells or exemptions not related to action on a permit, AE requests are typically treated as non-substantial program revisions.

**Operator**: Powertech (USA) Inc. (Powertech)

**Well/Project Name**: Dewey-Burdock Uranium ISR Project

**Well/Project Permit Number:** EPA Permit No. SD31231-00000

**Well/Project Location**: Portions of Sections 20, 21, 27, 28, 29, 30, 31, 32, 33, 34 and 35 of Township 6S, Range 1E and portions of Sections 1, 2, 3, 4, 5, 10, 11, 12, 14 and 15 of Township 7S, Range 1E

**County**: Custer and Fall River **State**: SD

**Well Class /Type:** Class III Uranium

## BACKGROUND

Powertech requested this AE as part of a Class III UIC Permit Application for the recovery of uranium from ore deposits in the Inyan Kara Group. The proposed Dewey-Burdock uranium ISR site is located in the southern Black Hills region in South Dakota on the South Dakota-Wyoming state line in southwest Custer and northwest Fall River Counties as shown in Figure 1. The site is located approximately 13 miles northwest of Edgemont, SD and 46 miles west of the western border of the Pine Ridge Reservation.

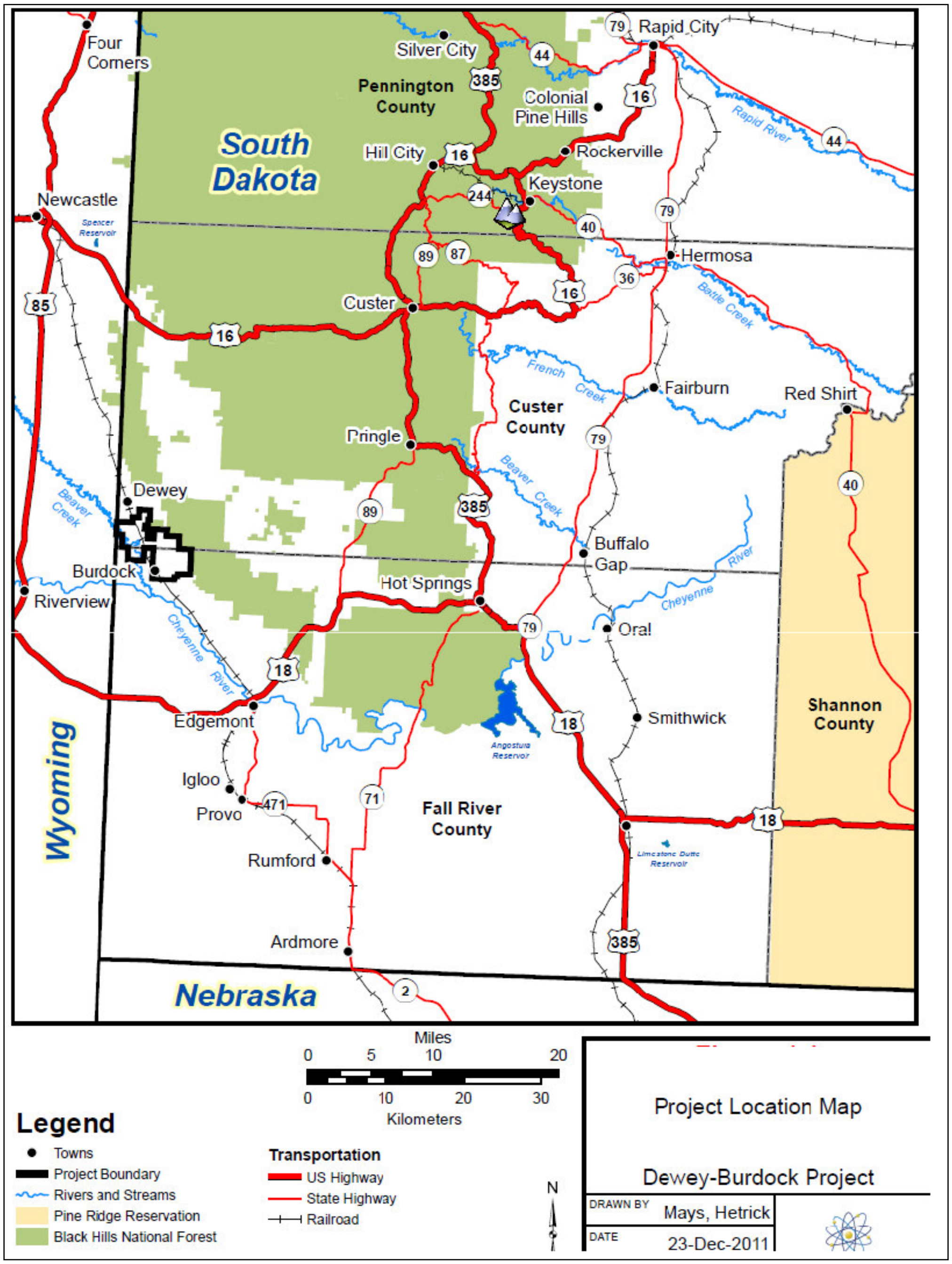



**Figure 1. Dewey-Burdock Project Location**

The project will involve the injection of lixiviant, consisting of injection interval groundwater with added oxygen and carbon dioxide, into the uranium ore deposits targeted by 14 proposed wellfields consisting of approximately 4,000 Class III injection wells. The lixiviant will mobilize uranium from the ore deposits and allow production wells to pump the uranium-bearing lixiviant out of the ground to a processing unit where the uranium will be removed from solution using an ion exchange resin. The barren lixiviant will be pumped from the processing unit back to the ISR wellfield where oxygen and carbon dioxide will be added before injection back into uranium ore deposits through the wellfield injection wells.

**DESCRIPTION OF PROPOSED AE**

**Aquifer to be Exempted**: Figure 2 shows the Dewey-Burdock Project Area outlined by the black Project Boundary. The Project Area is divided into the Dewey and Burdock Areas identified in Figure 2.

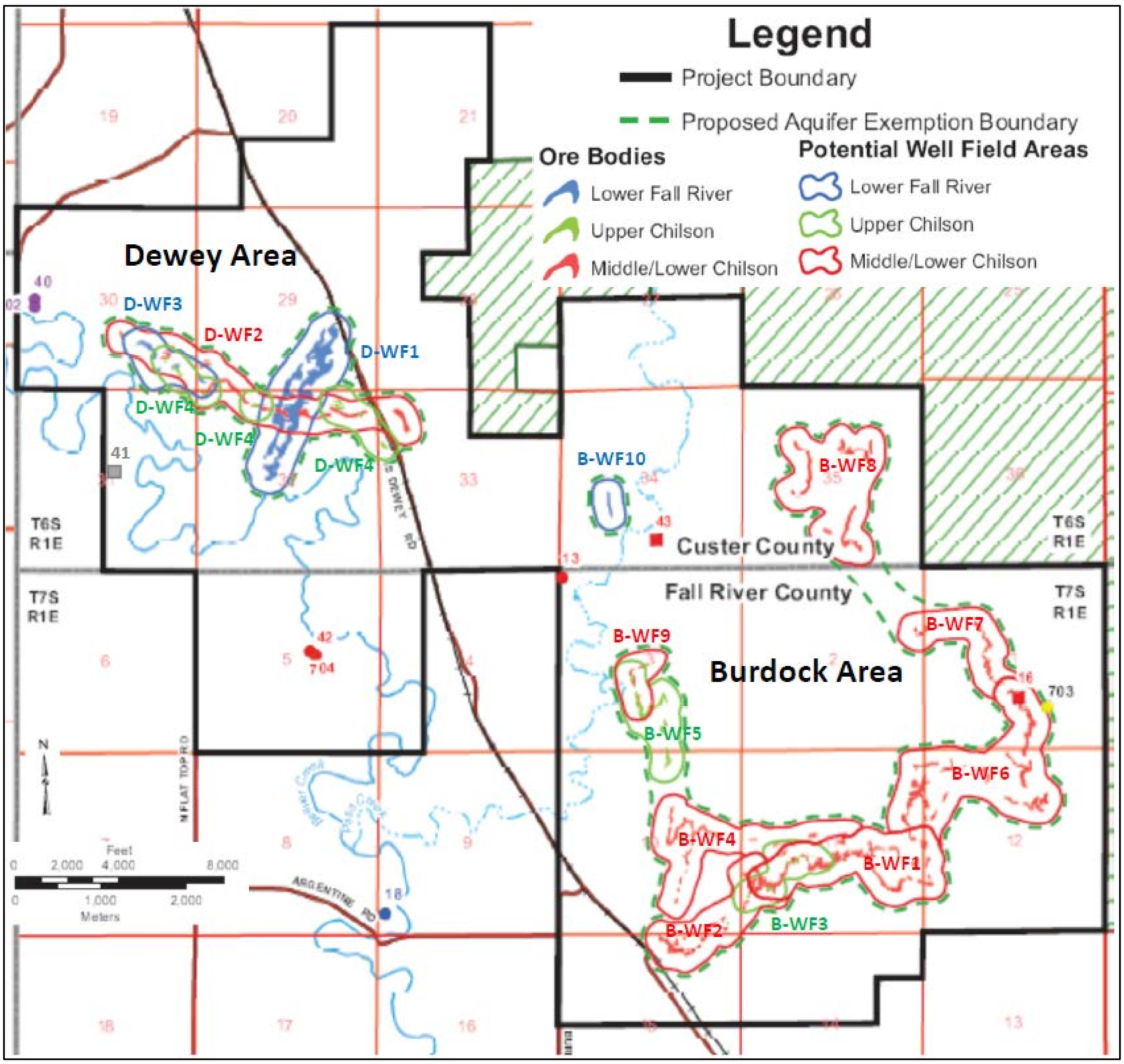



**Figure 2. Areas of the Inyan Kara Group Aquifers Proposed for Exemption.**

The aquifers proposed for exemption are the Inyan Kara Group aquifers: the Fall River Formation and the Lakota Formation, Chilson Sandstone Member. The horizontal extent of the exemption area requested by Powertech is outlined by the green-dashed boundary shown in Figure 2 surrounding the wellfield areas proposed for uranium recovery.

**Water Quality – Total Dissolved Solids (TDS) (mg/L)**:
Fall River Formation of the Inyan Kara Group: 773.85 mg/L-2,250.00 mg/L; mean TDS=1,275.01 mg/L, based on the summary of groundwater quality analyses in Appendix N of the Class III Permit Application.

Chilson Sandstone unit of the Lakota Formation of the Inyan Kara Group: 708.33 mg/L-2,358.33 mg/L; mean TDS=1,263.38 mg/L, based on the summary of groundwater quality analyses in Appendix N of the Class III Permit Application.

**Depth and Thickness of Aquifer (feet)**: In the Dewey-Burdock Project Area, the geologic strata dip gently to the southwest at 2 to 6 degrees; therefore, the depth to the top and bottom of the Inyan Kara Group aquifers varies across the Project Area. Table 1 presents an average depth of the Inyan Kara Group units in the Dewey and the Burdock Areas.

**Table 1. Depth below Ground Surface to the Top and Bottom of the Inyan Kara Group Units**

| Formation Name | Burdock Area | | | Dewey Area | | |
|---|---|---|---|---|---|---|
| | Top (ft) | Base (ft) | Thickness (ft) | Top (ft) | Base (ft) | Thickness (ft) |
| Inyan Kara Group | 190 | 425 | 235 | 525 | 760 | 235 |
| Fall River Formation | 190 | 315 | 125 | 525 | 650 | 125 |
| Lakota Formation | 315 | 425 | 110 | 650 | 760 | 110 |
| Fuson Shale | 315 | 355 | 40 | 650 | 690 | 40 |
| Chilson Sandstone | 355 | 425 | 70 | 690 | 760 | 70 |

The vertical extent of the Inyan Kara Group proposed for exemption includes the entire vertical interval which is confined above and below by low permeability shale confining zones.

**Areal Extent of the AE**: The areal extent of the proposed AE is approximately 2,260 acres and includes the areas shown in Figure 1.

**Confining Zone(s)**: Table 2 lists the major confining zones and their minimum and maximum thicknesses at wellfield locations within the Dewey-Burdock Project Area. The thickness values for the upper and lower confining zones for each of the exempted aquifers are based on logs from drillholes located throughout the Dewey-Burdock Project Area. These overlying and underlying confining zones are comprised of shale.

**Table 2. Major Confining Zones**

| Injection Interval | Confining Zone Formation Name | Minimum Thickness (ft) | Maximum Thickness (ft) |
|---|---|---|---|
| Fall River Sandstone | Upper Confining Zone: Graneros Group | 280 | 550 |
| | Lower Confining Zone: Fuson Shale | 20 | 80 |
| Chilson Sandstone | Upper Confining Zone: Fuson Shale | 20 | 80 |
| | Lower Confining Zone: Morrison Formation | 60 | 140 |

**Injectate Characteristics**: The injectate will be ISR lixiviant composed of injection interval groundwater with oxygen and carbon dioxide added.

**Regulatory Criteria for AE Request:** The EPA is proposing an exemption under the criteria at 40 CFR §146.4(a) and (b)(1), based on the determination that the proposed AE area:

(a) It does not currently serve as a source of drinking water; and

(b) It cannot now and will not in the future serve as a source of drinking water because:

(1) It is mineral, hydrocarbon or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.

Powertech, the UIC permit applicant, proposed the exempted area based on the location of commercially producible uranium ore plus a calculated distance of 120 feet beyond the perimeter monitoring well ring for each wellfield.

The horizontal extent of the AE area Powertech requested includes all currently identified potential Class III ISR wellfield areas, the perimeter monitoring well rings located 400 feet from the wellfield areas, and an additional area 120 feet outside of the perimeter monitoring well rings. As described in the September 2012 memorandum *Calculation of the Proposed Aquifer Exemption Distance beyond the Monitor Ring: Dewey-Burdock ISR Uranium Project, South Dakota*[1] (Petrotek Memorandum), this area is derived from a science-based calculation using site-specific properties of the injection interval aquifers and considers the distance that a potential excursion could travel prior to being detected and recovered. The Petrotek Memorandum states that the maximum distance that a potential excursion could travel before detection ($\Delta T$) is approximately 47 feet based on the geometry of the monitoring well rings. The estimated distance of potential excursion migration between initial detection and implementation of excursion recovery ($\Delta d$) is 24 feet based on a Darcy calculation using a hydraulic gradient representative of a wellfield imbalance that could cause an excursion. The dispersion factor

[1] Technical Memorandum to J. Mays, R. Blubaugh - Powertech Uranium, from: Hal Demuth – Petrotek "Calculation of the Proposed Aquifer Exemption Distance beyond the Monitor Ring: Dewey-Burdock ISR Uranium Project, South Dakota" September 12, 2012, included as Appendix M of the Class III Permit Application.

(DF) is estimated as 10% of the total travel distance or 47 feet. Adding these three distances together:

$\Delta T + \Delta d + DF = 47 \text{ feet} + 24 \text{ feet} + 47 \text{ feet} = 118 \text{ feet}$

This calculated distance that the AE boundary should be located outside the perimeter monitoring well ring was rounded up to 120 feet for ease of surveying and plotting on maps. A distance of 120 feet provides a reasonable extension beyond the monitoring ring boundary to enable uranium recovery while remaining protective of the USDWs located outside the exempted portions. For a more detailed explanation of the method Powertech used to determine the horizontal extent of the AE areas, see the Petrotek Memorandum, which is included in Appendix M of the Class III Permit Application.

## BASIS FOR DECISION

### Underground Sources of Drinking Water (USDWs)

UIC regulations found at 40 CFR § 144.3 defines an underground source of drinking water (USDW) as an aquifer or its portion:

(a) (1) Which supplies any public water system; or
(2) Which contains a sufficient quantity of ground water to supply a public water system; and
(i) Currently supplies drinking water for human consumption; or
(ii) Contains fewer than 10,000 mg/l total dissolved solids; and
(b) Which is not an exempted aquifer.

The Inyan Kara Group aquifers qualify as USDWs at this project site because the groundwater has a TDS concentration below 10,000 mg/L. The TDS concentrations of groundwater samples from different locations within the Fall River Formation and Chilson Sandstone aquifers are included in Appendix N of the Class III Permit Application. The TDS of the Fall River aquifer ranges between 773.85 mg/L-2,250.00 mg/L, with the mean TDS being 1,275.01 mg/L[2]. The TDS of the Chilson Sandstone aquifer of the Inyan Kara Group Lakota Formation ranges between 708.33 mg/L-2,358.33 mg/L with the mean TDS being 1,263.38 mg/L[3]. The TDS content and the capacity to produce a large enough volume of groundwater to supply a public water supply qualify Inyan Kara aquifers as USDWs; therefore an AE is required to inject under a Class III permit.

### Regulatory Criteria under which the exemption is approved

The EPA reviewed the information provided by Powertech to demonstrate the proposed AE area meets the regulatory criteria discussed below. Based on the information reviewed, the EPA has determined that the following regulatory criteria are met:

**40 CFR § 146.4(a)** *It does not currently serve as a source of drinking water*
Powertech reviewed historic records from Silver King Mines, Inc. and the Tennessee Valley Authority

[2] Class III Permit Application Appendix N, p. N-7
[3] Class III Permit Application Appendix N, p. N-11.

(TVA), conducted searches in the South Dakota Water Well database, the South Dakota Water Rights database and the Wyoming State Engineer's database and performed field investigations in order to compile an inventory of wells within approximately 2 km (1.2 miles) of the Dewey-Burdock Project Boundary. Figure 3 shows the locations of the 19 domestic wells identified within 2 km (1.2 miles) of the Project Boundary. A list of the complete well inventory is included in Appendix A of the Class III Permit Application. More detailed information on the well inventory and historic records searched is contained in Appendix B of the Class III Permit Application. The EPA determined that 2km (1.2 miles) from the Dewey-Burdock Project Boundary is an adequate distance for the well-search investigation because, as discussed later in greater detail, the capture zone for drinking water wells located outside the Project Boundary, but within the area 2 km (1.2 miles) from the Dewey-Burdock Project Boundary, did not intersect the AE boundary. This distance is greater than the minimum ¼ mile buffer zone from the AE boundary discussed in EPA Guidance #34.

**Private Drinking Water Wells inside the AE Boundary:** Powertech identified one private drinking water well inside the AE boundary. Well ID 16 is the only well located within the proposed AE boundary that has used the Inyan Kara groundwater for drinking water. No record of this well was found in the South Dakota water well databases. Powertech found information for this well in TVA records indicating that the well is 330 feet deep. Based on that depth, the well is completed in the Chilson Sandstone and is therefore drawing groundwater from a portion of the Inyan Kara aquifer proposed for exemption.

Powertech set up an agreement with the well owner that removed the well from drinking water use and supplies bottled water as drinking water to the well owner. Powertech disconnected the well from the residence by removing the pipeline between the well and the residence. The well will continue to be used for stock water until Powertech begins ISR operations. Powertech submitted a Water Well Completion Report to the South Dakota State Engineer which classifies the current well use as stock watering. Based on well usage alone, the EPA might conclude that this well does not currently supply Inyan Kara groundwater for use as drinking water for human consumption. However, under South Dakota regulations, the definition of domestic well includes stock watering as well as human drinking water. Under South Dakota regulation Chapter 46-1. Definitions and General Provisions, section 46-1-6, Definition of terms, (7) Domestic Use includes stock watering as well as drinking water for human consumption. Based on this regulatory definition, the well is still classified for use as a drinking water well. Therefore, classifying the well as a stock watering well does not draw a legal boundary excluding the well from potentially supplying human drinking water. Because of the lack of legal distinction between a stock watering well and a drinking water well, the EPA cannot make a definitive determination that well 16 does not currently supply Inyan Kara groundwater for use as drinking water for human consumption unless well 16 is plugged and abandoned.

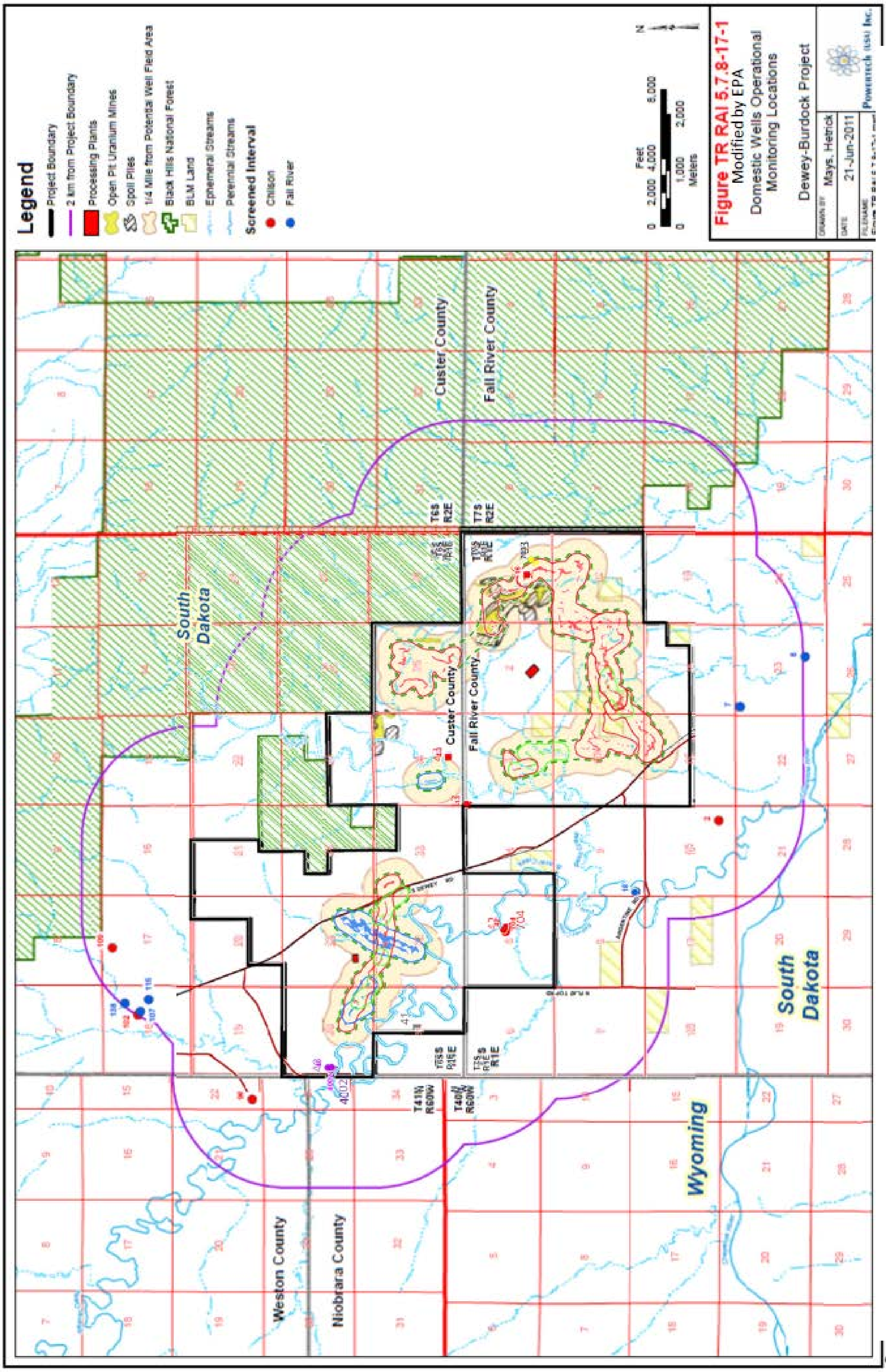



**Figure 3. Map of the Nineteen Private Drinking Water Wells Located within Approximately 2 km (1.2 Miles) of the Dewey-Burdock Project Boundary**

**Two Options for AE Approval:** For this reason, the EPA is offering and requesting comment on two options for approval of the AE area based on the status of well 16:

**Option 1** includes approval of the AE area shown in Figure 4, excluding the two Burdock Area wellfields (6 and 7) shown in blue in Figure 4. Powertech may request the exemption of Burdock wellfields 6 and 7 once well 16 is plugged and abandoned after the alternative water supply is in place. Both Burdock wellfields 6 and 7 are being excluded from this option because it appears that the southeastern end of Burdock wellfield 7 partially overlaps the northeast end of Burdock wellfield 6 in the area of well 16 as shown in Figure 4. Well 16 is located up-gradient of Burdock wellfields 1 and 8, which are the closest Burdock wellfields to well 16 outside of wellfields 6 and 7. Even though well 16 is located up-gradient of Burdock wellfields 1 and 8, the EPA calculated the capture zone width for well 16, as discussed below, to verify it does not cross the AE boundaries for Burdock wellfields 1 and 8.

**Option 2** allows Powertech to plug and abandon well 16 before the issuance of the final AE Record of Decision. After well 16 has been plugged and abandoned, the EPA will be in a position to determine that the groundwater within the AE boundary for Burdock wellfields 6 and 7 is not a current source of drinking water, and can approve the portion of the AE area shown in blue in Figure 4 as part of the final AE Record of Decision.

**Nearby Drinking Water Wells outside the AE Boundary:** It is also possible for water within the AE area to serve as a current source of drinking water for wells outside the AE boundary. In this case, the EPA looked for wells as far as 2 km (1.2 miles) beyond the Project Boundary. Based on the information available and the calculations performed, this was determined to be an appropriate distance. The technical analysis, described in detail below, demonstrated that water within the AE boundary is not a current source of drinking water for any existing wells.

Other than well 16, Figure 3 shows 18 drinking water wells located within 2 km (1.2 miles) of the Dewey-Burdock Project Boundary that are being used, or have been used, for drinking water. Ten of these wells are located outside the Dewey-Burdock Project Boundary. Nine wells (including well 16) are located inside the Project Boundary.

**Capture Zone Analysis:** A capture zone analysis (CZA) was performed for 11 private drinking water wells to evaluate whether any of these existing wells could draw groundwater from within the proposed AE area during the life of the well. CZA, in the context of this document, refers to the determination of the portion of the aquifer from which a well draws groundwater. The CZA process is described in the EPA *Technical Memorandum Documenting the Capture Zone Analysis for Eleven Private Drinking Water Wells in and near the Dewey-Burdock Uranium In-Situ Recovery Project Site Northwest of Edgemont, South Dakota* (EPA Technical Memorandum).

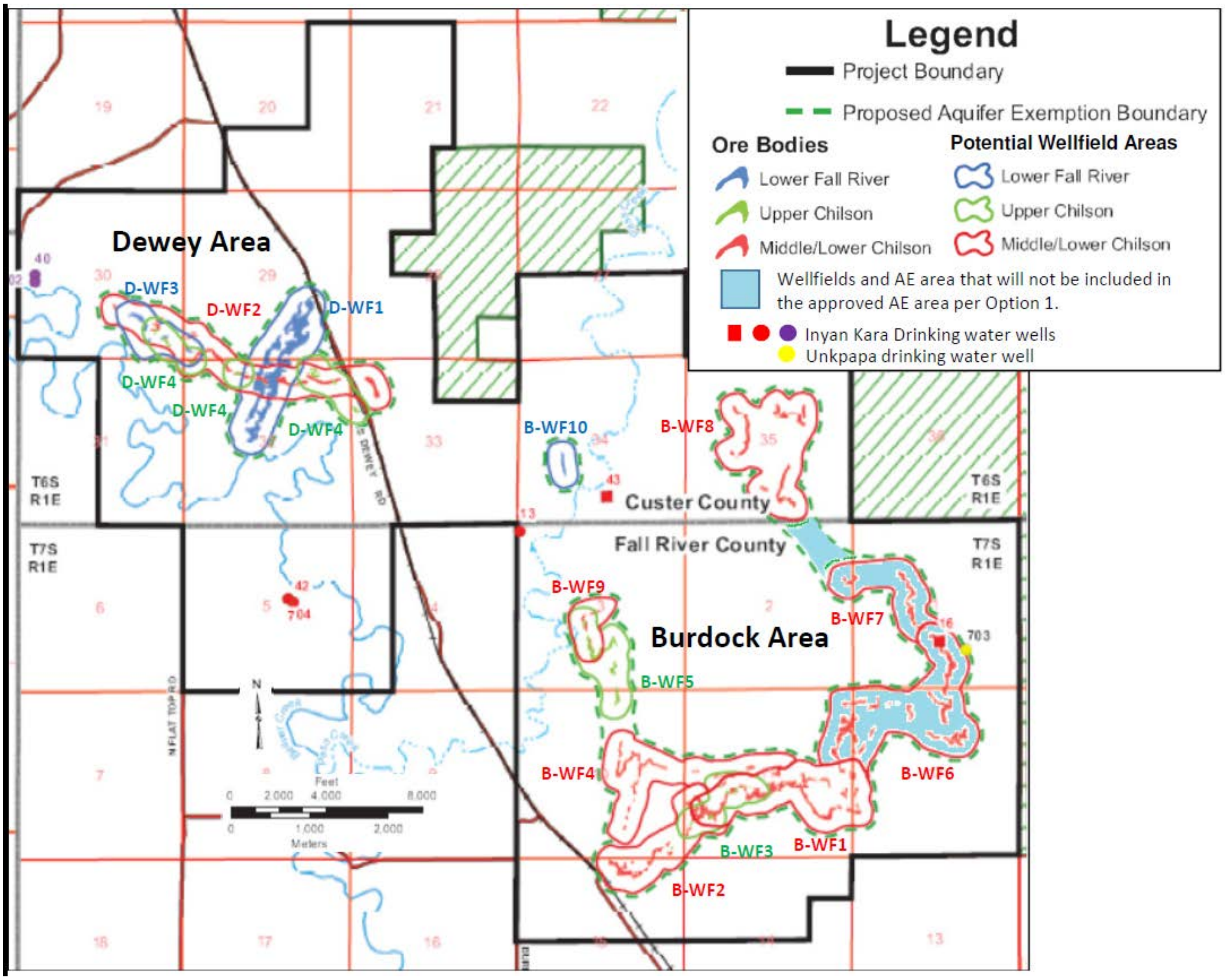



**Figure 4. Approved AE Area under Option 1.**

Of the ten wells located outside the project boundary, six wells are located up-gradient or cross-gradient relative to the direction of groundwater flow and the Project Boundary. As discussed in the EPA Technical Memorandum, no CZA was performed for these six wells. Based on the dimensions of the capture zones surrounding the wells that were analyzed, the captures zone for the six up-gradient and cross gradient wells would not extend far enough to cross the Dewey-Burdock Project Boundary.

No CZA was performed for two of the nine wells inside the project boundary. Well 703 is completed in the Unkpapa Sandstone. The Unkpapa Sandstone is not part of the Inyan Kara Group, which contains the aquifers proposed for exemption. The Unkpapa Sandstone is located stratigraphically below and is hydrologically separated from the Inyan Kara aquifers by the Morrison Formation lower confining zone. Because this well is not drawing groundwater from the any of the aquifers proposed for exemption, no CZA was needed for this well. Well 16 is located within the AE boundary and is drawing groundwater from the portion of the aquifer proposed for exemption in Burdock wellfields 6 and 7. To evaluate the potential for the capture zone of well 16 to cross the AE boundaries of the nearest Burdock wellfields outside wellfields 6 and 7, which are wellfields 1 and 8, the EPA calculated the width of the capture zone for well 16. The maximum capture zone width calculated for well 16 is 39 feet extending each side of the well. No up-gradient CZA was performed for well 16 because it is located up-gradient of Burdock wellfields 1 and 8.

Well 96 is located approximately 6,250 feet from the AE boundary for Dewey wellfield 2. No CZA was performed for well 96, because: 1) it is located cross-gradient and slightly up-gradient of the AE area: and 2) the largest capture zone width calculated for a well completed in the Chilson Sandstone aquifer is less than 6,250 feet.

The wells for which a CZA was performed include four wells located outside of and down-gradient from the project boundary and seven wells located inside the project boundary, but outside the proposed AE area.

The CZA was based on two equations: one equation calculates the up-gradient extent of the Zone of Contribution from a well pumping water from an aquifer with a sloping potentiometric surface and the second equation calculates the width of the capture zone. For a discussion of the first equation, see Section 4.4.3 of the EPA *Ground Water and Wellhead Protection Handbook*.[4] For a discussion of the second equation see Figure 4-10 from the EPA *Ground Water and Wellhead Protection Handbook.* Table 3 summarizes the information from the capture zone calculations for each well. For the purposes of this CZA, the ZOC is considered to be the capture zone for the pumping well. Appendix A of this document includes the equations and input values for the CZA for each well in Table 3.

The equation the EPA selected to calculate the up-gradient extent of the CZA is based on an underlying assumption that the well being analyzed is continuously pumping. This assumption results in a large overestimation of the calculated up-gradient extent of the well capture zone as discussed below. The second assumption the EPA used for the CZA is that the life of the well is based on the well construction date through 2047. The year 2047 was used because it is a time far enough in the future to allow for the completion of the Powertech ISR project. Both assumptions result in a very conservative over estimation of the up-gradient extent for each well's capture zone.

**Implications of Assuming a Continuously Pumping Well in the CZA**

As stated above, the assumption that the well is continuously pumping results in a very large over estimation of the up-gradient extent of the well capture zone. When a well is pumped continuously, the capture zone is continually expanding up-gradient over time. When a well stops pumping, the capture zone decreases in size as the aquifer potentiometric surface begins recovering from pumping. A private well is not pumped continuously; therefore, under actual conditions of private well use, the capture zone increases while the well is pumped, then decreases when well pumping stops. As a result of the underlying assumption of continuous pumping associated with the CZA equation the EPA used, the

[4] Ground Water and Wellhead Protection Handbook, EPA/625/R-94/001, September, 1994

capture zones calculated for each well in this analysis greatly overestimates the actual capture zone's up-gradient extent for an intermittently pumping private drinking water well.

**Flow Rates Used in the Capture Zone Equation:** The EPA evaluated two different scenarios for flow rate in the CZA equations. No records are available on actual domestic use pumping rates for the 11 private wells. Therefore, in the first scenario, the EPA used information available in well records or historic TVA records for flow rates from some of the wells that flowed naturally to the ground surface. These flow rates represent the maximum flow volume the well is capable of producing if it is allowed to flow to the ground surface under natural artesian conditions without pumping. For those wells for which no record of flow rate was available, the EPA used the maximum value allowed by the South Dakota State Engineer's Office for a private well without a water rights permit.[5] This flow rate is 18 gallons per minute (gpm) or 25,920 gpd and represents continuous pumping of these wells 24 hours a day. These flow rate values are extreme and greatly overestimate the flow rates expected for a well serving a single family residence.

For the second scenario, the EPA used the information available on the EPA Water Sense[6] website for residential water use. The website estimates that the average American family of four uses 400 gallons of water per day. The largest family in the Dewey-Burdock area consisted of 10 people, so the EPA increased the estimated water usage for each household with a private well to 1,000 gallons per day (gpd), which would be the expected usage for a household consisting of 10 people.

The EPA performed calculations using historic flow rates, if available, 25,920 gpd if no historic flow rate was available and a flow rate of 1,000 gpd for each capture zone calculation. Tables A-1 and A-2 in Appendix A of this document show the flow rates used as the input values for each well for which a CZA was performed. The calculations, input values and final results are included in Excel spreadsheets *CaptureZoneCalculations_2047*.pdf and *CaptureZoneCalculations_1000gpd_2047.pdf.*

Because wells 40 and 4002 are located so closely together, for the purposes of the CZA these two wells were considered to be one well, flowing at the combined rate of both wells. Similarly, wells 42 and 704 were considered to be one well flowing at the combined rate of both wells.

As discussed earlier, to verify that the capture zone for well 16 did not cross the AE boundaries for Burdock wellfields 1 and 8 under the AE approval, Option 1 scenario, the EPA calculated the capture zone width for well 16. Using both the 25,920 gpd and the 1,000 gpd flow rates, the largest capture zone width calculated for well 16 was 39 feet on each side of the well location. Therefore, the capture zone for well 16 does not cross the AE boundaries for wellfields 1 and 8.

Table 3 shows the results of the capture zone analyses. Using both the historic flow rate of 12 gpm (17,280 gpd) and the flow rate of 1,000 gpd for well 41 (Chilson completion) resulted in a capture zone

[5] None of the wells in question have a water rights permit; therefore, this is the maximum amount that they would be allowed to pump.
[6] http://www.epa.gov/WaterSense/pubs/indoor.html

| Well # | Calculated distances (ft) using well flow rates in Appendix A Tables A-1 and A-2 | | Calculated distances (ft) using 1,000 Gallons per Day | | Well location distance from nearest AE Boundary (ft) |
|---|---|---|---|---|---|
| | Maximum Upgradient Capture Zone Extent | Maximum Width of the Capture Zone | Maximum Upgradient Capture Zone Extent | Maximum Width of the Capture Zone | |
| 2 | 2,630′ | 3,655′ | 1,160′ | 141′ | 4,600′ downgradient from B-WF2 |
| 7 | 765′ | 2,460′ | 394′ | 402′ | 4,750′ crossgradient from B-WF2 |
| 8 | 7,269′ | 1,244′ | 5,269′ | 340′ | 9,625′ crossgradient from B-WF2 |
| 13 | 1,317′ | 299′ | 914′ | 207′ | 1,750′ downgradient from B-WF8 |
| 18 | 1,593′ | 3,917′ | 889′ | 340′ | 7,880′ downgradient from B-WF4 |
| 40 | 1,677′ | 2,074′ | 739′ | 144′ | 2,187.5′ crossgradient from D-WF2 |
| 41 (Fall River) | 1,554′ | 1,076′ | 795′ | 62′ | 2,750′ downgradient from D-WF 3<br>3,300′ crossgradient from D-WF1 |
| 41 (Chilson) | 4,246′ | 310′ | 2,924′ | 18′ | 3,000′ downgradient from D-WFs 2&4<br>3,300′ crossgradient from D-WF1 |
| 42 | 3,877′ | 909′ | 2,224′ | 35′ | 4,800′ downgradient from D-WF4 |
| 43 | 1,374′ | 4,873′ | 449′ | 188′ | 3,600 crossgradient from B-WF8<br>875′ crossgradient from B-WF10 |
| 704 | 3,877′ | 909′ | 2,224′ | 35′ | 4,800′ downgradient from D-WF4 |
| 4002 | 1,677′ | 2,074′ | 739′ | 144′ | 2,125′ crossgradient from D-WF2 |

**Table 3. Summary of Capture Zone Analysis for the Eleven Drinking Water Wells in and near the Dewey-Burdock Project Site.**

that extended up-gradient 1,246 ft and 910 ft, respectively, into the proposed AE area of Dewey wellfields 2 and 4. Because this calculation is based on the assumption the well is being pumped continuously through 2047, the resulting capture zone is a large overestimation of the up-gradient extent of the well's actual capture zone. As discussed above, when a well is pumped continuously, the capture zone is continually expanding up-gradient over time. When a well stops pumping, the capture zone decreases in size as the aquifer potentiometic surface begins recovering from pumping. A private well is not pumped continuously; therefore, under actual conditions of private well use, the capture zone increases while the well is pumped, then decreases when well pumping stops. In addition, the 12 gpm is the flow rate if the well were allowed to flow freely to the ground surface under natural artesian conditions. This flow rate is over 17 times the flow rate the EPA estimates for a family of ten based on information from the EPA Water Sense website. Well 41 has not been used for drinking water since at least 2006, when Powertech conducted the well survey for the Dewey-Burdock Project Area. The calculation the EPA performed to determine when the capture zone of a well would cross the AE boundary, using the 1,000 gpd flow rate, determined that the AE for well 41, if it is completed in the Chilson Sandstone and if it is pumped continuously, will not cross the AE boundaries for Dewey Wellfields 2 and 4 until the end of the year 2020 (see Table 3 in the EPA Technical Memorandum). However, as stated above, it is reasonable to assume that this private well would not be pumped continuously. Because continuous pumping is very likely the only scenario in which this well's capture zone would ever become large enough to cross the AE boundary, EPA concludes that the periodic pumping and recovery typical for private wells such as well 41 would prevent the well's capture zone from ever crossing the AE boundary. Therefore, the EPA is still able to conclude that the capture zone for well 41 does not cross the AE boundary.

Three wells, 43, 40 and 4002 are located cross-gradient from the AE area. For these wells, the width of the capture zone was calculated to determine if the capture zone is wide enough to intersect an AE boundary. As mentioned earlier, because wells 40 and 4002 are located so closely together, they were treated as one well with a flow rate equal to the sum of the flow rates of both wells for the purposes of calculating both the width and up-gradient extent of the capture zone. As explained in more detail in Appendix A of this document, the capture zone for wells 40 and 4002 is not wide enough to intersect the AE boundary.

Under the first flow rate scenario, using the State Engineer's maximum well flow rate before a water rights permit is needed of 25,920 gpd for well 43 resulted in a capture zone that encompassed all of Burdock wellfield 10 and extended 1,273 feet into the proposed AE area of Burdock wellfield 8. Additional calculations were performed for well 43 to determine the maximum flow rate that would result in the capture zone not crossing an AE boundary. Well 43 could pump up to 4,650 gpd before the width of its capture zone extended cross-gradient to reach the AE boundary of Burdock wellfield 10. The 25,920 gpd flow rate is over 25 times the flow rate the EPA estimates for a family of ten based on information from the EPA Water Sense website. Even the calculated flow rate of 4,650 gpd is over 4.5 time the estimated EPA flow rate for a family of ten. Similar to well 41, the well hasn't been used for drinking water since at least 2006, when Powertech conducted the well survey for the Dewey-Burdock

Project Area. Therefore, the EPA concluded that both flow rates, 17,280 gpd and 4,650 gpd, overestimate private well usage for well 43 completed in the Chilson Sandstone. As discussed earlier, even using a flow rate of 1,000 gpd results in a large overestimation of the upgradient extent of the well capture zone area, because the equation used for the CZA assumes a well is continuously pumping.

There are no public water system wells, including municipal wells, utilizing the Inyan Kara aquifers down-gradient of the Dewey-Burdock Project Area. The municipal wells owned by the City of Edgemont, which is approximately 13 miles down-gradient and to the southeast of the Project Area, are completed in the Madison Formation.

Based on the above results, the EPA has concluded that the portions of the Inyan Kara aquifers proposed for exemption do not currently serve as a source of drinking water.

**40 CFR § 146.4(b)(1)**
*It cannot now and will not in the future serve as a source of drinking water because:*

> *It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.*

Powertech provided information to the EPA to support the conclusion that the proposed AE area within the Inyan Kara aquifers cannot now and will not in the future serve as a source of drinking water by demonstrating in the Class III Permit Application for the uranium ISR operation that the portion of the aquifer proposed for exemption contains minerals in a quantity and location that is expected to be commercially producible.40 CFR § 144.7(c)(1) requires a UIC Class III Permit Application that "necessitates an aquifer exemption under 40 CFR §146.4(b)(1), to furnish the data necessary to demonstrate that the aquifer is expected to be mineral or hydrocarbon producing. Information contained in the mining plan for the proposed project, such as a map and general description of the mining zone, general information on the mineralogy and geochemistry of the mining zone, analysis of the amenability of the mining zone to the proposed mining method, and a time-table of planned development of the mining zone" should be considered by the UIC Director.

The commercial producibility of uranium from the Dewey-Burdock Project is demonstrated in the *Preliminary Economic Assessment of the Dewey-Burdock Project Area* (SRK, 2012). The Preliminary Economic Assessment was originally filed on July 14, 2010 and updated on February 8, 2011 and April 17, 2012. This document is published on SEDAR (System for Electronic Document Analysis and Retrieval) and is compliant with the National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101) of the British Columbia Securities Commission. The document was completed for Powertech by a consultant and confirms the resource calculations as well as the technical and economic viability of uranium recovery by ISR methods at the Dewey-Burdock Project. The average thickness of the uranium ore deposits targeted by the wellfields is 4.6 feet and the average grade is 0.21% $U_3O_8$ in the project area. Within the project area, Powertech has identified 14 wellfields that will be designed around economically viable uranium roll-front deposits occurring within the Fall River Formation and the Chilson Sandstone. The information in the report is based on the information from approximately 5,932 drillhole logs in and around the Dewey-Burdock Project Area. The TVA drilled and logged 5,823 exploratory drillholes to define the horizontal and vertical locations of the ore deposits; Powertech drilled and logged an additional 109 exploratory drillholes. The locations of the drillholes are listed in Appendix C of the Class III Permit Application.

Powertech provided cross sections based on the drillhole logs for each wellfield showing the thickness of the Inyan Kara aquifers, confining zones and overlying formations and the locations of the ore deposits. The drillhole logs are included in the cross sections. These cross sections are shown in Plates 6.13 through 6.21 of the UIC Class III Permit Application. Plate 6.12 is the cross section index showing a map with the locations of the cross sections through each wellfield.

**Demonstration of Amenability of Mining Method**

To demonstrate the amenability of the mining zone to the proposed ISR mining method, Powertech performed aquifer pump tests in the Dewey and Burdock areas and referred to pump tests performed by the TVA during the 1980s in the Fall River Formation and the Chilson Sandstone. The Powertech Dewey Area pumping well was completed in the Fall River Formation and the Powertech Burdock Area pumping well was completed in the Chilson Formation. The measurement of water levels in observation wells completed in the pumped aquifers confirmed that during all three pump tests a cone of depression formed in the pumped aquifer. The presence of a cone of depression verifies that hydraulic control of injection interval fluids is able to be maintained in wellfields in both Inyan Kara aquifers and demonstrates the amenability of the proposed ISR mining method. The UIC Class III Area Permit requires Powertech to perform similar pump tests for each wellfield to verify that hydraulic control of injection interval fluids is able to be maintained at each wellfield.

The thickness of the Inyan Kara Group averages approximately 350 feet within the project area. Within the proposed AE boundary, the Inyan Kara Group has the geologic and hydrologic features that make it a suitable host rock for the recovery of uranium using ISR methods as detailed Chapter 2 of the Nuclear Regulatory Commission (NRC) *Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities* (2009): (1) the deposit geometry is generally horizontal and of sufficient size and lateral continuity to economically extract uranium; (2) the sandstone host rock is permeable enough to allow the ISR solutions to access and interact with the uranium mineralization; and (3) the major confining zones (Graneros Group, Fuson Shale and Morrison Formation) plus local confining zones within the Fall River and Chilson aquifers, will prevent ISR solution from migrating vertically into overlying or underlying aquifers.

**Geochemistry and Mineralogy of the Mining Zone**

There are three distinct geochemical zones in the proposed exemption areas of the ore-bearing aquifers within the Dewey-Burdock project area: 1) the reduced zone, 2) the oxidized zone and 3) the ore zone.

The reduced zone is located down-gradient of the uranium ore deposits and represents the original character of the Inyan Kara sandstones before uranium mineralization occurred. The reduced sandstones are grey in color, pyritic and/or carbonaceous. Organic material consists of carbonized wood fragments and interstitial plant material. Pyrite is abundant within the host sandstones and present as very small cubic crystals or as very fine grained aggregates. Marcasite is also present as nodular masses in the sandstones. The pyrite contains trace amounts of transition metals (Cu, Ni, Zn, Mo and Se). Plagioclase and potassium feldspar clasts are fresh and, except for localized areas of calcite cementing, calcite is sparse, averaging only 0.15%. A heavy mineral suite (ranging from trace to 3%) of tourmaline, ilmenite, apatite, zircon and garnet is typical of those found in mature, quartz sandstones.

The oxidized zone occurs up-gradient of the uranium ore deposit and is characterized by the presence of iron oxides and oxyhydroxides resulting in a brown, pink, orange or red staining of host sandstones. The oxidized zone marks the progression of the down-gradient movement of mineralizing solutions through the host sandstones. Within the oxidized zone, pyrite has been altered and is present as hematite or goethite sand grain coatings, clastic particles or as pseudomorphs after the original pyrite crystal shape. Goethite is considered to be metastable and is found near the oxidation/reduction boundary, while the more stable hematite is found greater distances up-gradient from the ore zone. The heavy mineral leucoxene – a white titanium oxide – is also present as a pseudomorph of ilmenite. All organic material has been destroyed in the oxidized zone. The oxidizing solutions left dissolution etching on quartz grains and altered the feldspar minerals to clays.

The ore zone is located at the oxidation/reduction boundary where metals were precipitated when mineralizing solutions encountered an abrupt change from oxidizing conditions to reducing conditions as they moved down-gradient within the aquifers. Sandstones in this zone are greenish-black, black, or dark grey in color. The primary uranium minerals are uraninite and coffinite, which occur within pore spaces in the sandstone, coat sand grains and form intergrowths with montroseite (VO(OH)) and pyrite. Other vanadium (V) minerals (haggite and doloresite) are found adjacent to the uranium (U) mineralization, extending up to 500 feet into the oxidized portion of the system. Overall, the V-U ratios can be as high as 1.5:1.

Transition metals removed from the oxidized zone by the mineralizing solutions were precipitated at or adjacent to the oxidation/reduction boundary. Native arsenic and selenium are found adjacent to the uranium, in the up-gradient, oxidized boundary of the ore deposit filling pore spaces between quartz grains. Molybdenum occurs as the mineral jordisite adjacent to the uranium on the down-gradient, reduced boundary of the ore deposit. The relatively low concentrations of transition metals indicate their source could have been internal to the Inyan Kara sediments rather than having been introduced from the source of the uranium and vanadium.

### Project Timetable

Figure 5 is the proposed time table for project construction, operation and decommissioning included in the UIC Class III Permit Application. Powertech anticipates that the Dewey-Burdock uranium ore deposits will be commercially producible for eight years.

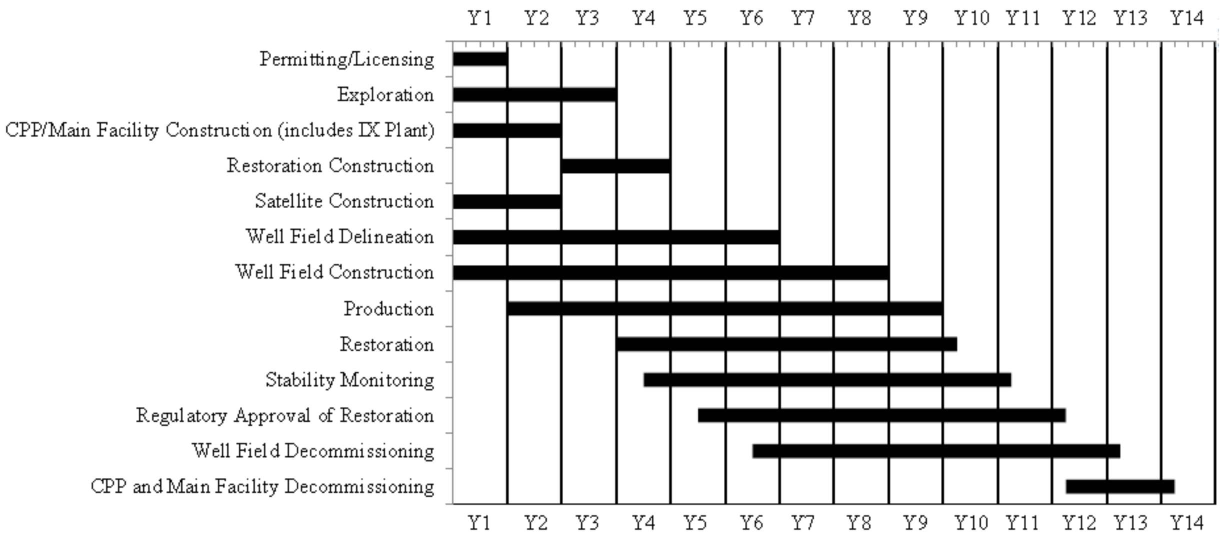



**Figure 5. Powertech's Time Table for Project Construction, Operation and Decommissioning**

## Ensuring Protection of Adjacent USDWs

### Demonstration that the Injection Zone Fluids Will Remain within the Exempted Portion

EPA guidance #34 states that if the exemption pertains to only a portion of an aquifer, a demonstration must be made that the waste will remain in the exempted portion. Such a demonstration should consider among other factors, the pressure in the injection zone, the waste volume, and injected waste characteristics (i.e., specific gravity, persistence, etc.) in the life of the facility. Given the nature of the ISR operation, waste fluids are not being injected into the exempted portion of the aquifer. The concern in the case of the ISR operation is whether or not contaminants from ISR activities will cross the AE boundary laterally or migrate vertically into USDWs. There were a number of factors leading the EPA to the conclusion that adjacent USDWs will not be impacted by ISR contaminants crossing the AE boundary laterally or migrating vertically. These factors include the following Class III Area Permit requirements:

- Injection interval confining zones will be evaluated during pre-ISR operation wellfield pump tests for their capacity to contain injection interval fluid vertically within the approved injection interval;
- Powertech must demonstrate the ability of the confining zones to contain injection interval fluids before the EPA will issue an authorization to commence injection;
- Powertech must demonstrate the ability of the monitoring network to detect any movement of injection interval fluids out of the approved injection interval before the EPA will issue an authorization to commence injection;
- Hydraulic control of the wellfield must be maintained by injecting a smaller volume of lixiviant

into the wellfield injection interval than is pumped out. Hydraulic control will be verified by continuous monitoring of injection rate and volume and the measurement of water levels in the wellfield perimeter monitoring well ring to verify a cone of depression.

- The extensive monitoring well network will verify both lateral and vertical containment of injection interval fluids. If any injection interval fluids begin to migrate out of the approved injection interval, the water level measurements in the monitoring well network will provide early detection to allow Powertech to implement timely corrective response actions to reverse the migration.
- The source material license issued by the NRC requires post-ISR groundwater restoration stability monitoring. After the post-ISR groundwater restoration stability monitoring period has been completed for each wellfield, the EPA Class III Area Permit requires Powertech to conduct post-restoration monitoring to ensure that no ISR contaminants cross the AE boundary.

**Vertical confinement:** Throughout most of the project area the Inyan Kara Group is bounded above by shale units of the Graneros Group which serve as the uppermost confining zone for ISR operations. The depth to the top of the Inyan Kara Group ranges from approximately 0 feet where the Fall River Formation crops out in the eastern portion of the Burdock Area to 550 feet below ground surface in the Dewey Area. Analysis of a core sample from the Skull Creek Shale unit of the Graneros Group shows the vertical hydraulic conductivity to be very low: $5.39 \times 10^{-9}$ cm/s, compared with the vertical hydraulic conductivity of the Chilson Sandstone, $1.35 \times 10^{-3}$ cm/s or the Fall River Formation sandstone, $4.77 \times 10^{-4}$ cm/s.

As shown in Figure 6, the Graneros Group Shales are absent in the eastern portion of the Burdock Area where the Fall River Formation outcrops at the surface in the area shown in blue. Portions of Burdock Wellfields 6, 7 and 8 are located where the Fall River Formation outcrops and the Graneros Group shales are absent. However, these wellfields will be targeting ore in the Middle and Lower Chilson Sandstone shown in the cross section of Figure 7. No wellfields will be targeting ore in the Fall River Formation where the overlying Graneros Group confining zone is absent. The Fuson Shale, which separates the Chilson Sandstone from the overlying Fall River Formation, acts as the upper confining zone for the Chilson Sandstone as shown in Figure 7.

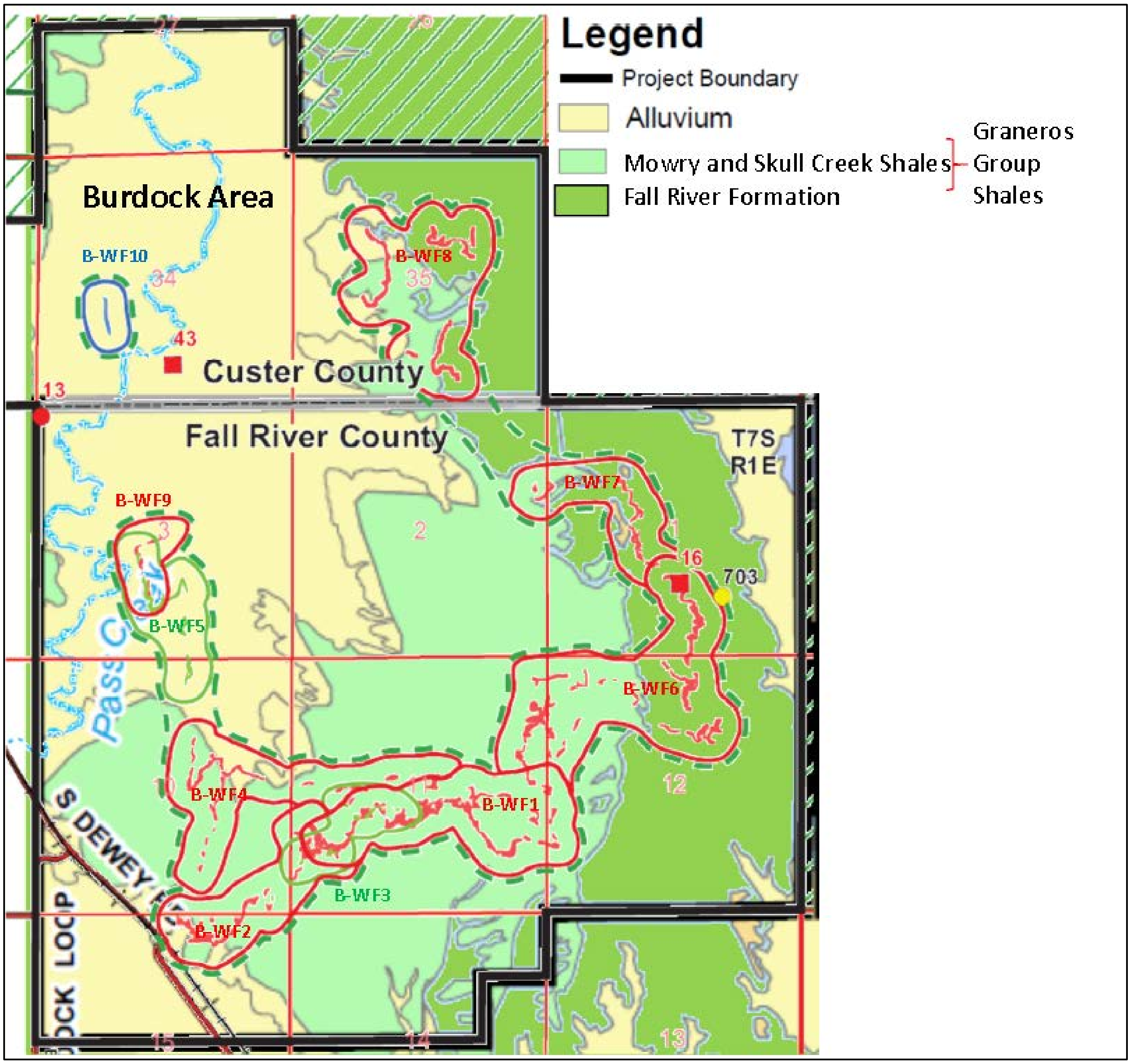



**Figure 6. Map Showing Surface Geology of the Burdock Area and Burdock Area Wellfields.**

Figure 7 shows a portion of cross-section B-B' through Burdock wellfield 6. The complete cross-section B-B' can be viewed in Plate 6.14 of the Class III Permit Application. Figure 7 shows the Fuson Shale upper confining zone for the Chilson Sandstone and the shale units separating the Upper, Middle and Lower Chilson. The average thickness of the Fuson Shale is about 50 feet thick in this area. The vertical hydraulic conductivity of the Fuson Shale measured in core sample ranges from $6.16 \times 10^{-9}$ to $1.76 \times 10^{-7}$ cm/s.

Results from aquifer pump tests conducted in the Chilson Sandstone by Powertech and the TVA indicated that there is a hydraulic connection between the Fall River Formation and the Chilson Sandstone that would call into question the integrity of the Fuson Shale as an upper confining zone to

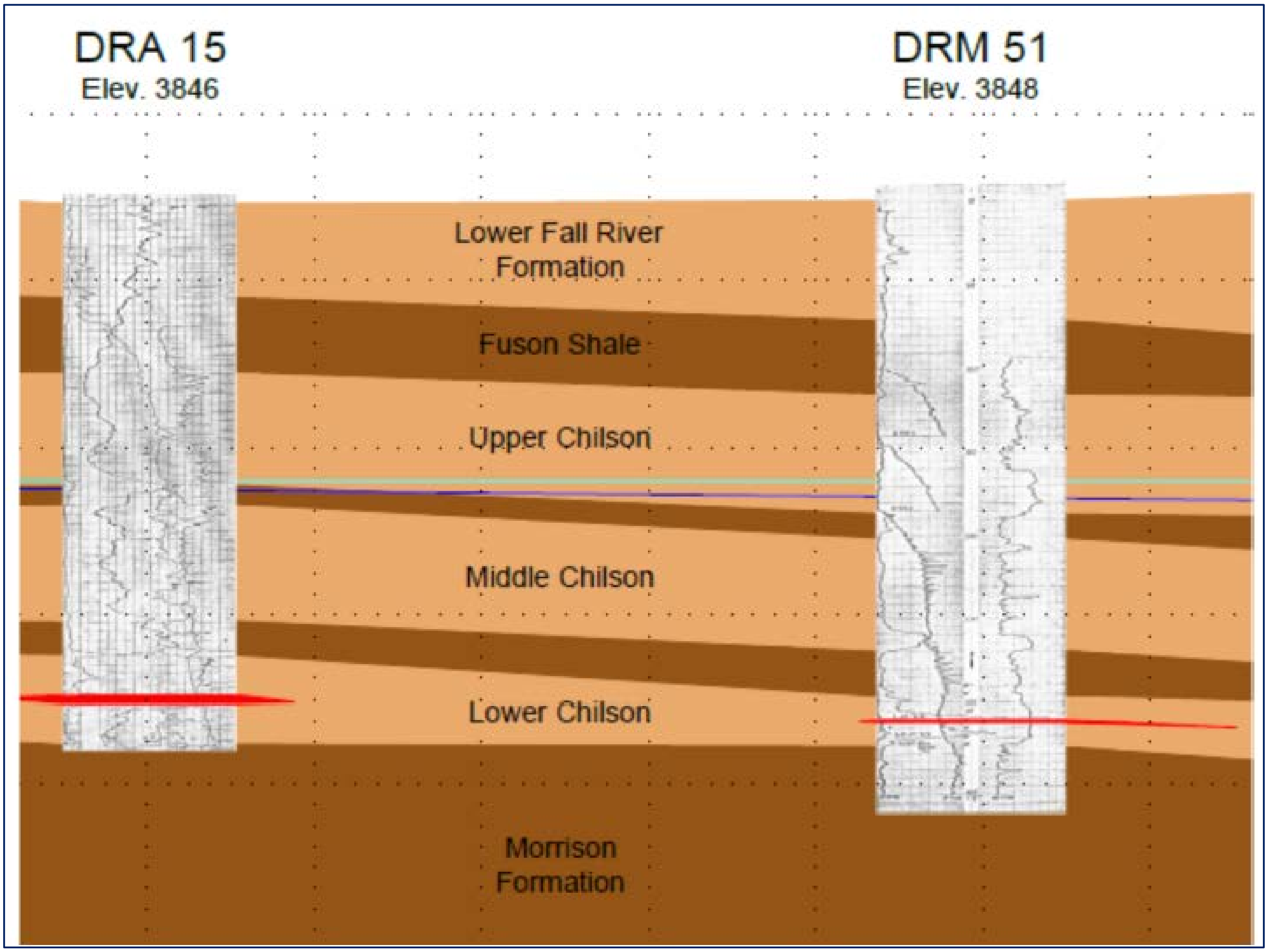


**Figure 7. Portion of Cross Section B-B' from Plate 6.14 of the UIC Class III Permit Application.**

the Chilson Sandstone. The UIC Class III Area Permit requires thorough investigation of the overlying confining zone for each wellfield before the EPA will authorize any injection activities. Section 5.0 of the UIC Class III Area Permit Fact Sheet discusses the wellfield characterization requirements, including characterization of the confining zones for each wellfield. If a confining zone breach is caused by an improperly plugged historic exploratory drillhole or a well causes a pathway through a confining zone, the UIC Class III Area Permit requires Powertech to take corrective action to prevent the breach from resulting in the vertical migration of injection interval fluids out of the injection interval. The UIC Class III Area Permit Fact Sheet contains more information about possible breaches in confining zones in Section 4.6 and a discussion of the required corrective action is found in Section 6.0.

The Morrison Formation is the lower confining zone for the Inyan Kara Group. It is a low-permeability shale unit with a thickness of 60 to 140 feet at the Dewey-Burdock Project Site. Analyses of core samples from the Morrison Formation have shown the vertical permeability to be very low and range from $3.9 \times 10^{-9}$ to $4.2 \times 10^{-8}$ cm/s.

To verify that no wellfield fluids migrate vertically out of the approved injection interval, non-injection interval monitoring wells will be completed within each wellfield in the overlying and underlying hydrogeologic units. Because the Morrison Formation is a thick and impermeable confining zone, the Class III Area Permit does not require monitoring of the aquifer underlying the Morrison Formation during wellfield operation or restoration. However, the Class III Area Permit requires at least one observation well below the Morrison Formation to be monitored during wellfield pump tests, to verify the integrity of the Morrison Formation as a confining zone in that area. Analytical results of groundwater samples collected from the overlying and underlying monitoring wells will provide baseline water quality data from which the compliance limits for the overlying and underlying aquifers will be established. These wells will be monitored during wellfield operation, post-ISR groundwater restoration and post-restoration monitoring to detect any potential vertical migration of ISR solutions out of the approved injection interval. The EPA may require additional overlying or underlying monitoring wells beyond the minimum density specified in the Class III Area Permit to detect potential vertical excursions in areas where the integrity of a confining zone is in question.

The Class III Area Permit requires Powertech to demonstrate mechanical integrity for all wells installed, including injection, production and monitoring wells, to ensure that the cement-filled annulus between the well casing and drillhole wall does not contain any channels that could potentially allow migration of injection interval fluids out of the injection interval through confining zones.

**Lateral Confinement:** The Class III Area Permit requires Powertech to demonstrate and maintain hydraulic control of injection interval fluids during the uranium recovery process and post-ISR groundwater restoration. To accomplish this, the wellfield pumping rate must exceed the injection rate resulting in net extraction of injection interval fluids. As explained later in the monitoring requirements section of this document, continuous monitoring of injection and production flow rates and volume is required for each wellfield to verify that these conditions are being met.

The net extraction of injection interval fluids creates a cone of depression within each wellfield indicating that an inward hydraulic gradient is pulling groundwater into the wellfield. The measurement of water levels in observation wells during the pump tests performed by both the TVA and Powertech demonstrate that a cone of depression formed in the pumped aquifer during the pump tests. The presence of a cone of depression verifies that hydraulic control of injection interval fluids is able to be maintained within Inyan Kara aquifers. The required monitoring of water levels in the wellfield perimeter monitoring well ring verifies that the cone of depression is being maintained during wellfield operations and post-ISR groundwater restoration.

A combination of monitoring and response actions required during the operational, post-ISR groundwater restoration and the post-restoration phases will assure that any effects from the ISR operations will remain within the exempted portion of the aquifers. As discussed in the following section, monitoring wells will be installed in and around each wellfield, up- and down-gradient and in overlying and underlying aquifers, to detect the potential migration of ISR solutions away from the approved injection interval.

**Monitoring Requirements:** The UIC Class III Area Permit requires Powertech to maintain hydraulic control of injection interval fluids within each wellfield at all times to prevent any horizontal movement of lixiviant out of the wellfield and includes a rigorous monitoring program to verify hydraulic control. For a more detailed discussion of the monitoring requirements, see Section 12 of the Fact Sheet for the Class III Area Permit.

**A perimeter monitoring well ring** will be completed in the ore zone injection interval aquifer around each wellfield. These wells will be used to verify the existence of the cone of depression through monitoring the water level in each well. A rise in water level detected in any well will signal an incipient loss of hydraulic control allowing it to be corrected before any lixiviant actually moves out of the approved injection interval. Groundwater sampling at the perimeter monitoring well ring will detect any potential horizontal migration of fluid outside the wellfield. Perimeter monitoring wells will be located no farther than 400 feet from the wellfield, evenly spaced with a maximum spacing of either 400 feet or a spacing that will ensure a 70 degree angle between adjacent perimeter monitoring wells and the nearest injection well as illustrated in Figure 8.

**Operational groundwater monitoring** will be conducted to detect potential changes in groundwater quality in and around the project area as a result of ISR operations. The operational groundwater monitoring program will include domestic wells, stock wells and wells located hydrologically up-gradient and down-gradient of ISR operations. Wells to be included in the operational monitoring program include domestic wells within 2 km (1.2 miles) of the Project Area Boundary, stock wells within the Project Area, and additional monitoring wells within the project area in the alluvial, Fall River, Chilson and Unkpapa aquifers.

**Monitoring within the wellfield during groundwater restoration** will be conducted in accordance with the NRC license until the ISR-impacted groundwater meets Target Restoration Goals, or groundwater concentration limits, set in the license. The purpose of groundwater restoration monitoring is to track the progress of aquifer restoration by sampling ore zone monitoring wells within each wellfield at a frequency sufficient to determine the success of aquifer restoration, optimize the efficiency of aquifer restoration, and determine if any areas need additional attention. The UIC Class III Area Permit does not have any requirements related to monitoring groundwater within the wellfield during restoration because it does not contain any restoration target concentration limits for wellfield groundwater. The UIC Class III Area Permit has post-restoration groundwater permit limits that must be met at the AE boundary or an alternate compliance boundary instead of inside a wellfield.

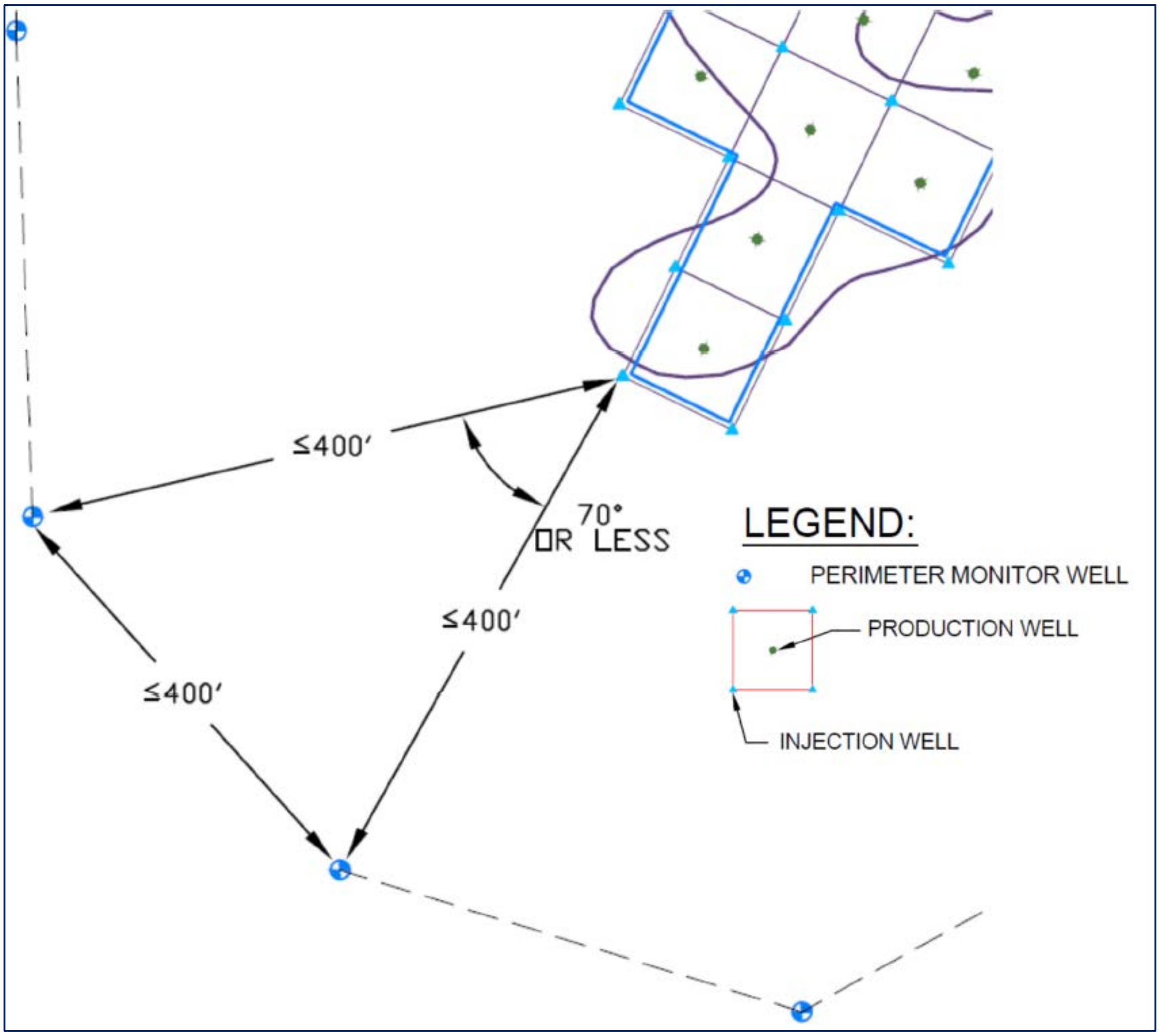



**Figure 8. Spacing between Perimeter Monitoring Wells Will Be No Greater than 400 Feet or Close Enough to Ensure a 70 Degree Angle between Adjacent Perimeter Monitoring Wells and the Nearest Injection Well**

**A groundwater stability monitoring period after restoration** will be conducted in accordance with the NRC license to show that the restoration goal is adequately maintained within the wellfield after groundwater restoration is complete. The stability monitoring period in the current NRC license includes 12 months with quarterly sampling (at least five sample events, including one at the beginning of the stability monitoring period and after each of the following four quarters). If a constituent does not meet the stability criteria, Powertech must take appropriate action consistent with the constituent and the status of the restored groundwater system. Potential actions may include extending the stability period or returning the wellfield to a previous phase of active restoration to resolve the issue. If the analytical results from the stability period continue to meet the NRC license Target Restoration Goals and meet the stability criteria, then Powertech will submit supporting documentation to the NRC showing that the restoration parameters have remained at or below the restoration standards and requesting that the wellfield be declared restored. As with monitoring inside the wellfield during active restoration, the UIC

Class III Area Permit does not contain any requirements for post-restoration groundwater stability monitoring within a wellfield.

**Post-restoration groundwater monitoring** is required by the UIC Class III Area Permit to verify that contaminants do not cross the AE boundary into the USDW. Under UIC regulations, “contaminant” means any physical, chemical, biological, or radiological substance or matter in water. For the purposes of post-restoration groundwater monitoring under the Class III Area Permit, a contaminant will be any constituent that was not present in the USDW before the ISR process was initiated (as determined by baseline monitoring required under the UIC Class III Area Permit) or any increase of statistical significance above the mean baseline concentration of any constituent present in the USDW.

The EPA requirements for post-restoration monitoring proposed in the Class III Area Permit address the prohibition of ISR contaminants crossing the AE boundary. The Class III Area Permit requires that once wellfield groundwater reaches a down-gradient contaminant boundary, there is a three-year period of stability monitoring to evaluate whether ISR contaminant concentrations are demonstrating an increasing trend which might result in violation of groundwater baseline levels at the down-gradient AE boundary.

## OTHER CONSIDERATIONS

The EPA evaluated the groundwater quality of the Inyan Kara aquifers within the area proposed for exemption and the likelihood that Inyan Kara groundwater within the AE boundary would be used for drinking water at some time in the future. Analytical results from the Inyan Kara aquifer groundwater samples are included in Appendices N and O of the Class III Permit Application. As stated earlier, the TDS of the Fall River Formation of the Inyan Kara Group ranges between 773.85 mg/L-2,250.00 mg/L, with a mean TDS of 1,275.01 mg/L; the TDS of the Chilson Sandstone unit of the Lakota Formation of the Inyan Kara Group ranges between 708.33 mg/L-2,358.33 mg/L, with a mean TDS of 1,263.38 mg/L. Inyan Kara groundwater requires treatment by reverse osmosis to decrease TDS, iron, manganese and sulfate concentration below the secondary drinking water standards before is it palatable for human consumption. In addition to these taste and odor concerns, Inyan Kara wells completed within the ore zone also have radium, gross alpha and radon concentrations above MCLs.

The water for the City of Edgemont, which is approximately 13 miles southeast of the Project Area, is supplied from municipal wells completed in the Madison Formation. Reverse osmosis is an expensive option for a public water system to use. Reverse osmosis treatment also generates a large volume of concentrated reject brine that would require disposal. The City of Edgemont chose to drill an additional 2,400 feet to complete wells in the Madison Formation instead of using Inyan Kara groundwater for the public water supply.

The land use in the Dewey-Burdock Project Area is mainly grazing for cattle ranches. It is unlikely that the population will increase in that area to a size that would support a public water system. According to www.census.com, the population of Edgemont has decreased since 2000: in the 2000 census, the population was 867; in 2010, it was 774; in 2015, the estimated population was 739. Based on this information, it is unlikely that the Inyan Kara groundwater within the AE boundary would be used in the future to supply drinking water.

**CONCLUSION AND DECISION**

Based on review of the information Powertech provided, the EPA finds that exemption criteria 40 CFR § 146.4(a) and 146.4(b)(1) have been met except for the proposed AE area surrounding Burdock wellfields 6 and 7 shown in blue in Figure 4. The EPA approves the AE request as a minor/non-substantial program revision for the rest of the proposed AE area and provides two options for approval of the AE area surrounding Burdock wellfields 6 and 7.

**Appendix A**
**CZA Information**

Equation number 4-7 in Section 4.4.3 Time of Travel with Sloping Regional Potentiometric Surface in the EPA *Ground Water and Wellhead Protection Handbook* was used to determine the up-gradient extent of the capture zone.

**Handbook** **EPA/625/R-94/001**
**September 1994**

**Ground Water and Wellhead Protection**

***4.4.3 TOT With Sloping Regional Potentiometric Surface***

$$t_x = n/Ki\,[r_x - (Q/2\pi Kbi)\ln\{1 + (2\pi Kbi/Q)r_x\}] \quad (4\text{-}7)$$

where
$t_x$ = travel time from point x to a pumping well
n = porosity
$r_x$ = distance over which ground water travels in $T_x$, $r_x$ is positive (+) if the point is upgradient, and negative (–) is downgradient

Q = discharge
K = hydraulic conductivity
b = aquifer thickness
i = hydraulic gradient

Transmissivity (T) was used in the equation instead of hydraulic conductivity (K) and aquifer thickness (b).
Transmissivity T=Kb

Table A-1 shows the information on age and historic flow rate information for each well. As described in the ROD, if no information on the construction date of the well was available in historic records, the age of the oldest well was used. The older the well, the larger the capture zone. The two scenarios for flow rate are described earlier in this document.

Table A-2 shows all the values used for all variables in the capture zone equation. Table 3 shows the calculated up-gradient extent of each capture zone using both scenarios for flow rate. Table 3 also shows the distance each well is located down-gradient from an AE boundary. So as not to call into question the exact down-gradient flow direction up-gradient from each drinking water well, the distance to the closest AE boundary was used for comparison to the calculated extent of the capture zone included in Table 3. As discussed earlier, because wells 40 and 4002 are located so closely together, they were treated as one well with a flow rate equal to the sum of the flow rates of both wells for the purposes of calculating up-gradient extent and the width of the capture zone. Similarly, because wells 42 and 704 are located so closely together, they were treated as one well with a flow rate equal to the sum of the flow rates of both wells for the purposes of calculating up-gradient extent and the width of the capture zone.

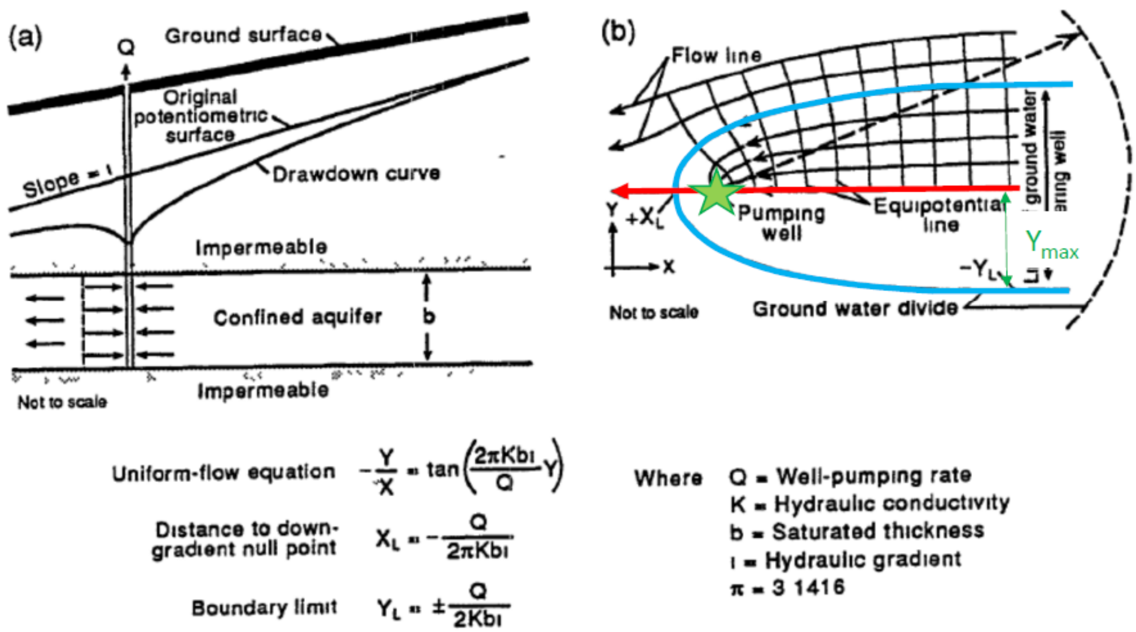
| Well ID# | Sec,Township Range | Screened Interval & Project Site Area | Distance & Direction from Aquifer Exemption Boundary | Year Constructed/# Years & Days of Operation through 2047 | Historic Values for Flow rate gpm |
|---|---|---|---|---|---|
| 2 | SESE Sec 16<br>T7S R1E | Chilson<br>Burdock | 4,600' downgradient<br>from B-WF2 | 1930s, Use 1930<br>43,100 days | 30 gpm which is greater than the SEO allows without water rights permit<br>Use 18 gpm / 25,920 gpd |
| 7 | NWNW Sec 23<br>7S 1E | Fall River<br>Burdock | 4,750' crossgradient<br>from B-WF2 | Late 1950s, Use 1958<br>32,873 days | 4.25 gpm<br>6,120 gpd |
| 8 | SWSE Sec 23<br>23 7S 1E | Fall River<br>Burdock | 9,625' crossgradient<br>from B-WF2 | Well repair form 1951. Casing had corroded away. Assume original well drilled in 1930<br>43,100 days | 2.5 gpm<br>3,600 gpd |
| 13 | NWNW Sec 3<br>T7S R1E | Chilson<br>Burdock | 1,750' downgradient<br>from B-WF10 | 1950s, Use 1950<br>35,795 days | Notice of well construction says well flows at 1 gpm, 1,440 gpd |
| 18 | SWSW Sec 9<br>T7S R1E | Fall River<br>Burdock | 7,880' downgradient<br>from B-WF4 | Late 1920s to early 1930s<br>Use 1930<br>43,100 days | 8 gpm<br>11,520 gpd |
| 40 | SWNW Sec 30<br>T6S R1E | Inyan Kara<br>Dewey | 2,187.5' crossgradient<br>from D-WF2 | 1969<br>28,855 days | 2 gpm<br>2,880 gpd |
| 41 | SWNE Sec 31<br>T6S R1E | Fall River<br>Dewey | 2,750' downgradient From D-WF3<br>3,300' crossgradient from D-WF1 | No information<br>Use 1930; 43,100 days | 12 gpm<br>17,280 gpd |
| 41 | SWNE Sec 31<br>T6S R1E | Chilson<br>Dewey | 3,000' downgradient From D-WFs 2&4<br>3,300' crossgradient from D-WF1 | No information<br>Use 1930; 43,100 days | 12 gpm<br>17,280 gpd |
| 42 | SWNE Sec 5<br>T7S 1E | Chilson<br>Dewey | 4,800' downgradient<br>From D-WF4 | 1949<br>36,160 days | Flows 30 gpm, Use 18 gpm<br>25,920 gpd |
| 43 | SWSE Sec 34<br>T6S R1E | Chilson<br>Burdock | 3,600' crossgradient from B-WF8<br>875' crossgradient from B-WF10 | No information<br>Use 1930; 43,100 days | No info Use 18 gpm<br>25,920 gpd |
| 704 | SWNE Sec 5<br>T7S 1E | Chilson<br>Dewey | 4,800' downgradient<br>From D-WF4 | 2008<br>14,611 days | No info Use 18 gpm<br>25,920 gpd |
| 4002 | NWSW Sec 30<br>T6S R1E | Inyan Kara<br>Dewey | 2,125' crossgradient<br>from D-WF2 | 1940s Use 1940<br>39,448 days | No info Use 18 gpm<br>25,920 gpd |

**Table A-1. Well Location Information and the Values for Well Age and Flow Rate Used in the Capture Zone Equation.**

| Well ID# | Sec, Township Range | Screened Interval | Transmissivity (T) ($ft^2$/day) | Porosity (n) (%) | Hydraulic Gradient (i) (ft/ft) | Aquifer Thickness b (ft) | Age of well at end of 2047 (days) | Flow Rate (gpd) |
|---|---|---|---|---|---|---|---|---|
| 2 | SESE 16 T7S R1E | Chilson Burdock | 150 & 190 | 0.296 & 0.319 | 0.00316 | 63 | 43,100 | 25,920 & 1,000 |
| 7 | NWNW Sec 23 7S 1E | Fall River Burdock | 54 & 255 | 0.29 | 0.00308 | 186 | 32,873 | 6,120 & 1,000 |
| 8 | SWSE Sec 23 23 7S 1E | Fall River Burdock | 54 & 255 | 0.29 | 0.00364 | 20 | 43,100 | 3,600 & 1,000 |
| 13 | NWNW 3 T7S R1E | Chilson Burdock | 150 & 190 | 0.296 & 0.319 | 0.00215 | 45 | 35,795 | 1,440 & 1,000 |
| 18 | SWSW 9 T7S R1E | Fall River Burdock | 54 & 255 | 0.29 | 0.00364 | 128 | 43,100 | 11,520 & 1,000 |
| 40 | SWNW 30 T6S R1E | Inyan Kara Dewey | 255 | 0.29 | 0.00364 | 150 | 28,855 | 2,880 & 1,000 |
| 41 | SWNE Sec 31 T6S R1E | Fall River Dewey | 255 | 0.29 | 0.00421 | 165 | 43,100 | 17,280 & 1,000 |
| 41 | SWNE Sec 31 T6S R1E | Chilson Dewey | 590 | 0.296 & 0.319 | 0.00631 | 140 | 43,100 | 17,280 & 1,000 |
| 42 | SWNE 5 7S 1E | Chilson Dewey | 590 | 0.296 & 0.319 | 0.00646 | 150 | 36,160 | 25,920 & 1,000 |
| 43 | SWSE 34 T6S R1E | Chilson Burdock | 150 & 190 | 0.296 & 0.319 | 0.00237 | 145 | 43,100 | 25,920 & 1,000 |
| 704 | SWNE 5 7S 1E | Chilson Dewey | 590 | 0.296 & 0.319 | 0.00646 | 150 | 14,611 | 25,920 & 1,000 |
| 4002 | NWSW 30 T6S R1E | Inyan Kara Dewey | 255 | 0.29 | 0.00364 | 150 | 39,448 | 25,920 & 1,000 |

**Table A-2. The Input Values for All Variables in the Capture Zone Equation, Distance and Direction Each Well Is Located from nearest AE Boundary and the Calculated Extent of the Capture Zone.**

To calculate the capture zone width, the boundary limit equation was used as shown below in Figure A-1 which is Figure 4-10 from the EPA *Ground Water and Wellhead Protection Handbook.* The groundwater divide shown as the blue line is the outer boundary of the capture zone for the well represented by the green star in the figure below. All groundwater outside the blue groundwater divide will flow past the well. All groundwater inside the blue groundwater divide will flow to the well. The groundwater divide is calculated using the uniform-flow equation shown in Figure 4-10. The boundary limit equation calculates the maximum width measured from the red capture zone centerline attained by groundwater divide. This maximum width is called $Y_{max}$. For the wells located cross-gradient from an AE boundary, wells 40, 4002 and 43, $Y_{max}$, must be calculated for the capture zone. For wells 40 and 4002, $Y_{max}$ was smaller than the nearest AE boundary. As discussed earlier, because wells 40 and 4002 are located so closely together, $Y_{max}$ was calculated using the combined flow rate of the two wells.




Transmissivity (T) was used in the equation instead of hydraulic conductivity (K) and aquifer thickness (b). Transmissivity T=Kb

**Figure A-1. Illustration of the Boundary Limit Equation used to Calculate the Maximum Width of the Well Capture Zone.**

More detailed information on the CZA is provided in the *Technical Memorandum Documenting the Capture Zone Analysis for Eleven Private Drinking Water Wells in and near the Dewey-Burdock Uranium In-Situ Recovery Project Site Northwest of Edgemont, South Dakota* included in the Administrative Record for the Dewey-Burdock permitting and AE actions.