EPA REGION 8'S RESPONSE TO PETITION FOR REVIEW

Attachment H

Doc 264, Draft Aquifer Exemption Record of Decision (August 26, 2019)

U.S. EPA Region 8

Underground Injection Control Program

PROPOSED AQUIFER EXEMPTION RECORD OF DECISION

This 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 In-Situ Recovery (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 U

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 southwest of the Black Hills 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.

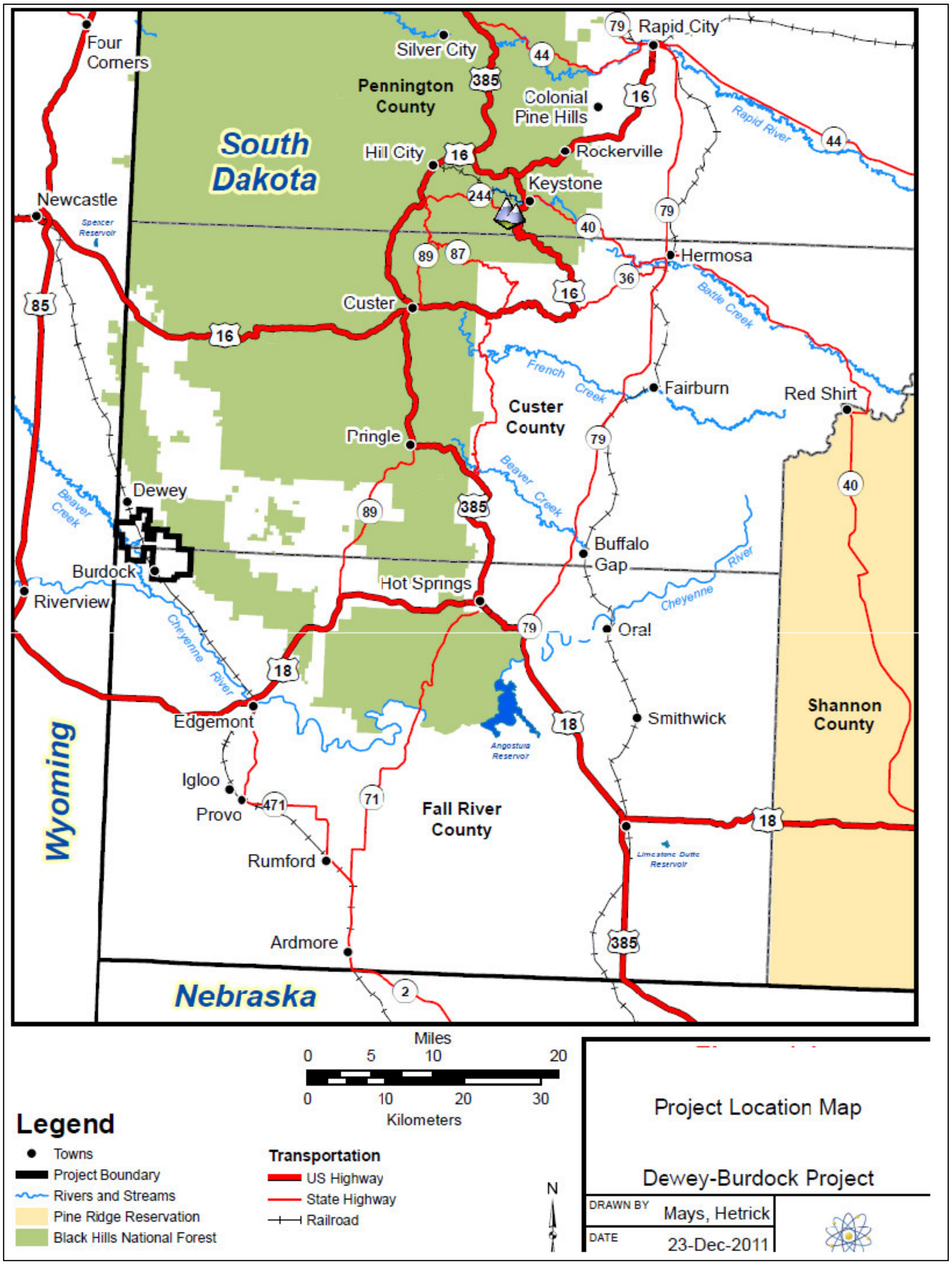


Figure 1. Dewey-Burdock Project location

The ISR process involves the injection of lixiviant, consisting of injection interval groundwater with added oxygen and carbon dioxide, into uranium ore deposits targeted by 14 proposed wellfields. Powertech anticipates the construction of approximately 1,461 Class III injection wells and 869 production wells over the life of the project. The lixiviant is injected through the injection wells and mobilizes uranium from the ore deposits. Production wells pump the uranium-bearing lixiviant out of the ground. The uranium-bearing lixiviant flows via pipeline from the wellfield to a processing unit where ion exchange resin columns remove the uranium from solution. The barren lixiviant is pumped from the processing unit back to the ISR wellfield where oxygen and carbon dioxide are added before injection back into uranium ore deposits through the wellfield injection wells. The production wells will be regulated as injection wells under the Class III Area Permit, because they may serve as injection wells at some point during the life of the project.

The Class III Area Permit requires a perimeter ring of monitoring wells completed in the injection zone around each wellfield as shown in Figure 2. The color of the ore deposits and the perimeter monitoring well rings indicates where the ore deposits occur vertically in the aquifer. The perimeter monitoring well ring is located about 400 feet from the injection and production wells completed in the ore deposits. The proposed AE boundary, represented by the green dashed line, is located 120 feet outside of the perimeter monitoring well ring.

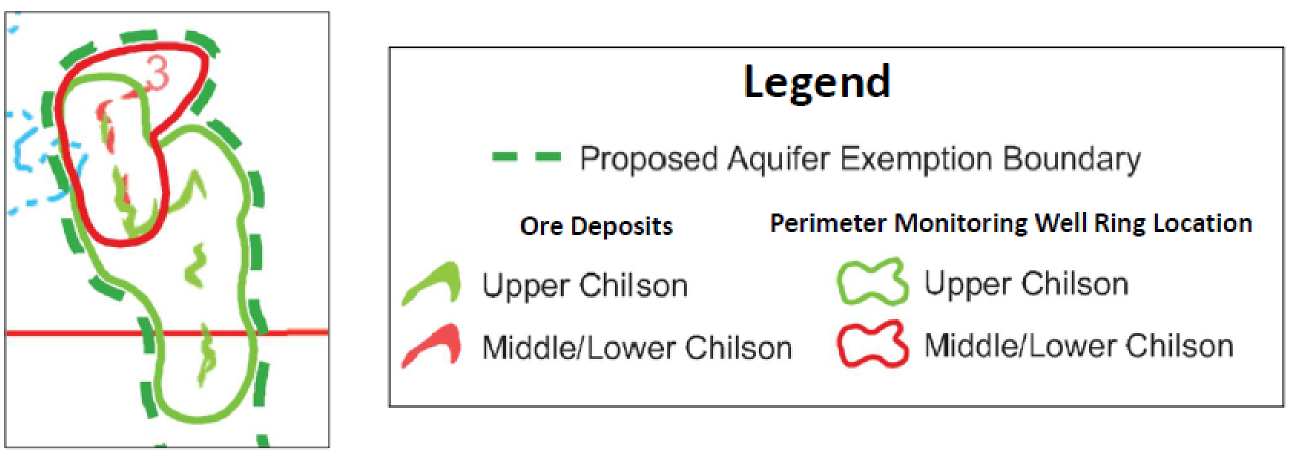


Figure 2. Wellfield diagram showing the locations of the uranium ore deposits, perimeter monitoring well rings and the proposed AE boundary.

DESCRIPTION OF PROPOSED AE

Aquifer to be Exempted: Figure 3 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 3. 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 line shown in Figure 3 surrounding the wellfield areas proposed for uranium recovery. The green-dashed AE boundary line is set 120 feet from the perimeter monitoring well rings. After delineation drilling identifies the horizontal extent of the ore deposits in more detail, the ore deposits may be slightly larger than they are shown in Figure 3. Based on the horizontal expansion of the ore deposits, the perimeter monitoring well rings may move slightly outward from the location shown in Figure 3, because they are located 400 feet from the injection and production wells completed in the ore deposits. A shift of the perimeter monitoring well rings would result in a corresponding shift of the AE boundary, because it is located 120 from the perimeter monitoring well rings. Powertech does not expect the shift in the AE boundary to extend farther than the boundary located ¼-mile away from the ore deposit boundaries shown in Figure 3. Therefore, the maximum possible extent of the final AE boundary would be the line ¼-mile away from the ore deposits as shown in their current locations in Figure 3. In most cases, the AE boundary will not extend that far. In order to extend the AE boundary past the ¼-mile boundary, Powertech would be required to submit a new AE application, which would trigger the public review process.

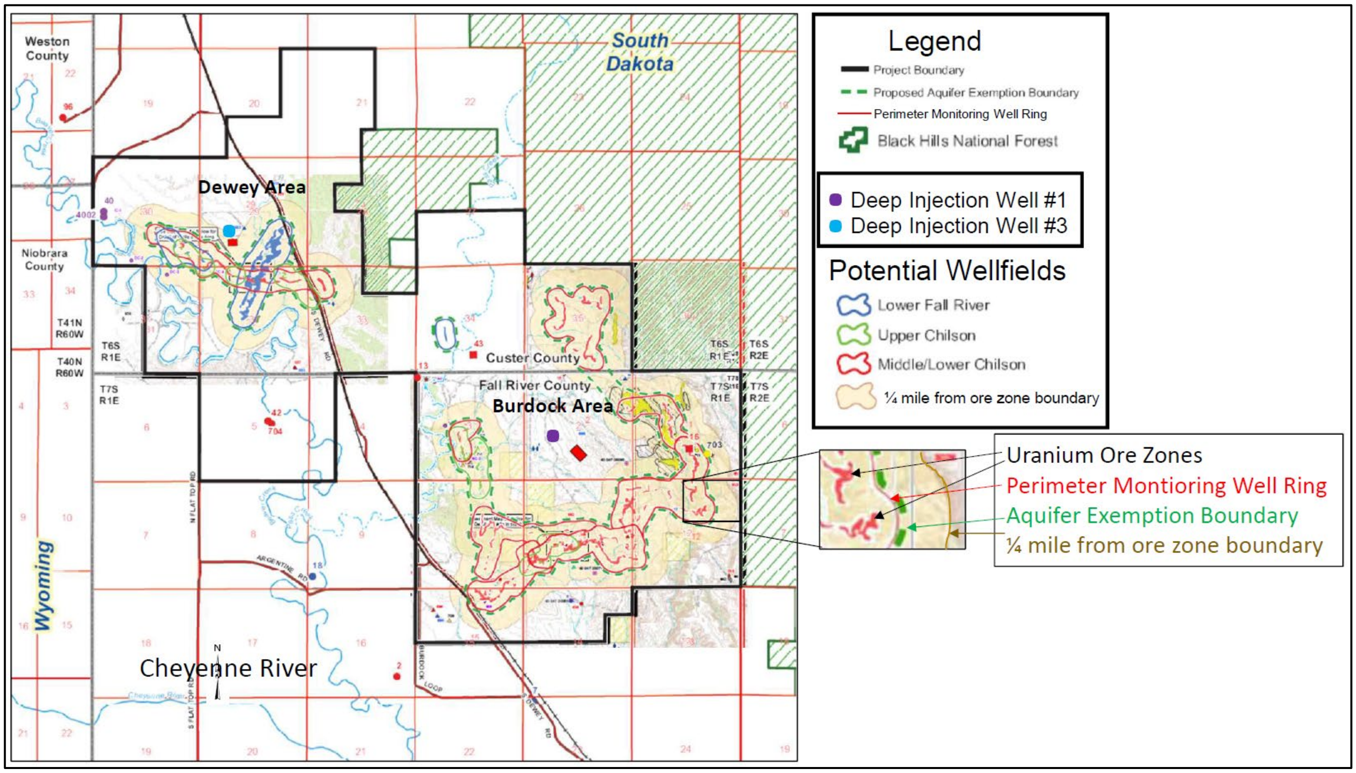


Figure 3. Areas of the Inyan Kara Group aquifers proposed for exemption.

Placing the AE boundary 120 feet from the perimeter monitoring well ring is the same approach as proposed in the previous 2017 AE Record of Decision document. The EPA is now clarifying that the AE boundary may shift slightly outward from the location shown in Figure 3. The AE boundary will not shift beyond the boundary located ¼-mile from ore deposits as they are shown in Figure 3.

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 3.

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

There are also operational confining units for each wellfield consisting of unnamed shale units separating the Upper and Lower Fall River Formation and the Upper, Middle and Lower Chilson

Sandstone, as shown in Figure 4. These local confining units direct the injected lixiviant so that it flows through the ore deposit in the intended injection interval.

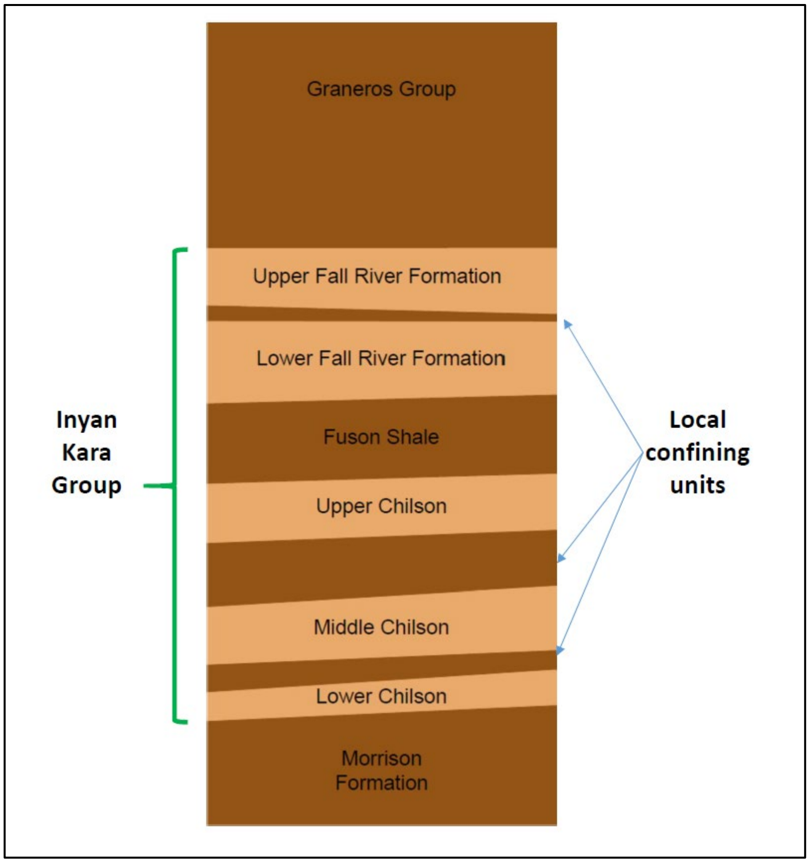


Figure 4. Stratigraphic column of the Inyan Kara Group, major confining zones, and the local confining units.

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) Is not currently a source of drinking water

(b)(1) Cannot now and will not in the future be 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, 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], 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 maximum distance that a potential excursion could travel before detection (ΔT) 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 (Δd) 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 (DF) is estimated as 10% of the total travel distance or 47 feet. The science-based calculation of 118 feet for ΔEb 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 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.

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

Regulatory Criteria under which the exemption is approved

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 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 (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 5 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. As shown in Figure 6, well 16 is completed in a uranium ore deposit.

Powertech analyzed the groundwater produced from well 16 and found radium and gross alpha are above the primary drinking water standards, and radon is also high. Once the well owners became aware of the fact that groundwater from well 16 was high in radium, gross alpha and radon, they entered into an agreement with Powertech to remove the well from drinking water use. Powertech 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 law, a well used for stock watering is still classified as a domestic well, and a domestic well can be used for human drinking water. (See SD Codified L § 46-1-6).

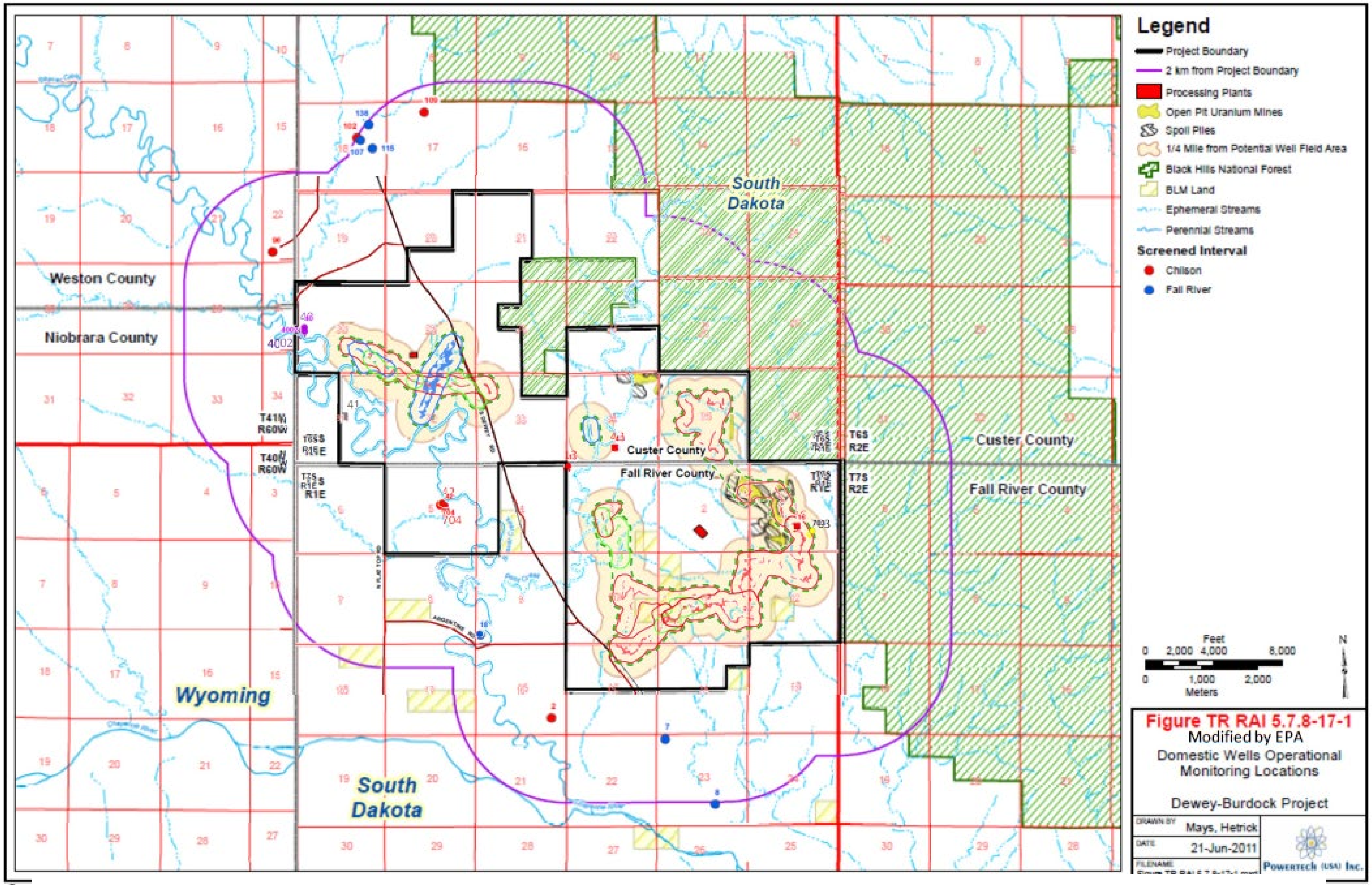


Figure 5. Map of the nineteen private drinking water wells located within approximately 2 km (1.2 miles) of the Dewey-Burdock Project Boundary

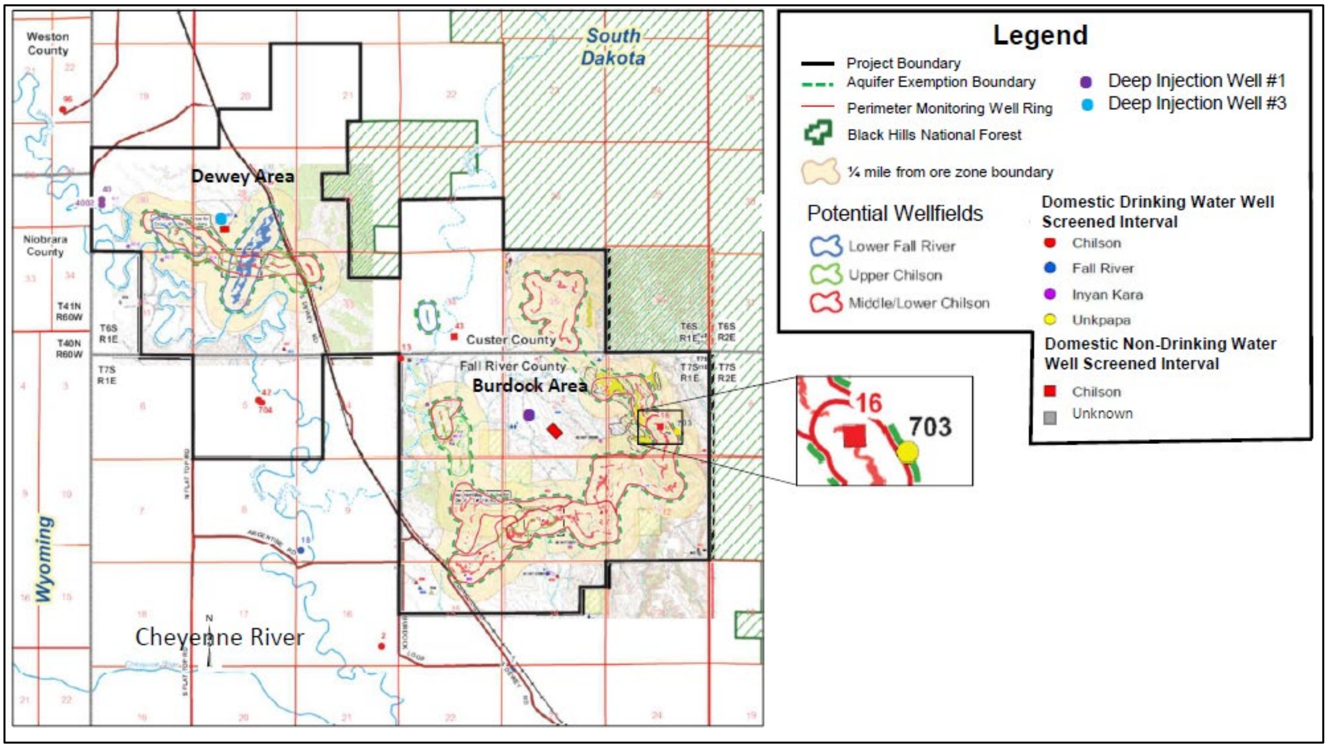


Figure 6. Location of well 16 in Chilson uranium ore deposit.

Because of the lack of distinction between a stock watering well and a drinking water well under South Dakota law, 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. Therefore, the EPA is seeking input on the following three options regarding the AE in the area of well 16.

Three Options for AE Approval: For this reason, the EPA is offering and requesting comment on three 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 7, excluding the two Burdock Area wellfields (6 and 7) shown in blue in Figure 7. Powertech plans to provide an alternative water supply to well owners inside the project boundary. 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 7.

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 7 as part of the final AE Record of Decision.

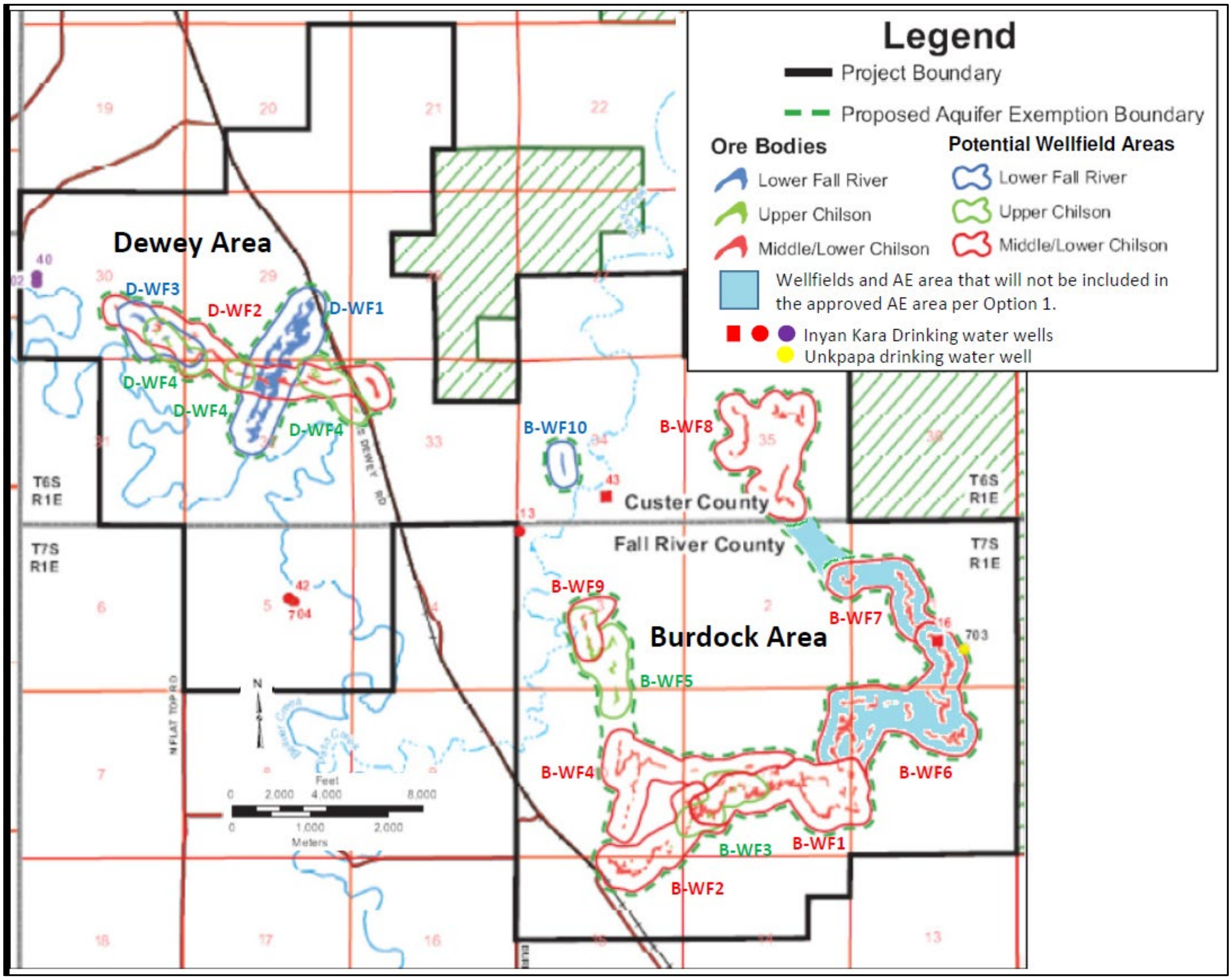


Figure 7. Approved AE Area under Option 1.

Option 3 allows Powertech to submit a South Dakota Water Well Completion Report to classify well 16 as a monitoring well and attach documentation stating that well 16 should not be used for human consumption because the groundwater produced from the well exceeds the primary drinking water standards for radium and gross alpha and radon levels are high enough that indoor use should be avoided. Upon submission of this Report by Powertech and reclassification of the well use by the State, the EPA can then approve the portion of the AE area shown in blue in Figure 7 as part of the final AE Record of Decision.

More specifically, under Administrative Rules of South Dakota (ARSD) 74:02:04:20 (34), the definition of a monitoring well is "a cased well used for measuring groundwater levels or collecting water samples." Reclassifying the well as a monitoring well would remove it from classification as a domestic well in South Dakota's database. Powertech would attach documentation to the South Dakota Water Well Completion Report stating that well 16 should not provide water for human consumption and indoor use because the groundwater produced from the well exceeds the primary drinking water standards for radium and gross alpha and radon levels are high enough that indoor use should be avoided.

If the aquifer exemption is approved for the area shown in blue in Figure 7, the Class III Area Permit requires Powertech to submit additional documentation to the State to specify that the Chilson aquifer at that site has been exempted from protection under the Safe Drinking Water Act through the aquifer exemption process at 40 CFR § 146.4. The South Dakota State Engineer's office would include this information in the well files for future well owners to access. Therefore, if anyone later reclassified the well as a domestic water well through the State, they would receive notice of the water quality and lack of SDWA protection.

Once Powertech begins construction of Burdock wellfields 6 and 7, well 16 will be under Powertech's control. The Class III Area Permit requires Powertech to secure the wellhead with a locking cover to restrict access to the well.

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, 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.

Including well 16, Figure 5 shows 19 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.

Of the ten wells located outside the Project Boundary, six wells are located upgradient or crossgradient relative to the direction of groundwater flow and the Project Boundary. As discussed in the *Technical Memorandum*, no CZA was performed for these six well wells.

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 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. Because well 16 is drawing water from inside the AE boundary, no CZA was performed for this well.

The wells for which a CZA was performed include four wells located outside of and downgradient 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 upgradient 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. Appendix A of this document includes the equations and input values for the CZA for each well in Table 3.

In performing the calculations, the following assumptions were made: 1) the drinking water well is constantly pumping and 2) the life of the well from its construction date through 2017 was used for the pumping interval. The assumption that the well is continuously pumping results in a very conservative approach for the areal extent of the capture zone, because this is the maximum amount of time the well could pump and domestic wells are generally not pumped continuously. The capture zone for a well that is continuously pumping is constantly growing larger over time. The capture zone for a well that is pumping intermittently expands while the well is pumping but decreases during the time the well is not pumping and the aquifer potentiometric surface is recovering. As a result, the capture zone for a continuously pumping well is much larger than for a well that is intermittently pumping.

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, EPA used the information available on the EPA Water Sense[5] website for residential water use. The website estimates that the average American family of four uses 400 gallons of water per day. On average, approximately 70% of that water is used indoors, with the bathroom being the largest consumer (a toilet alone can use 27%). 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. An estimated flow of 1,000 gpd is a conservative overestimation for drinking water usage, because it includes 30% expected for outdoor usage and the remaining 70% includes other indoor uses such as laundry, bathing and toilet use.

For the second scenario, 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 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.[6] This flow rate is 18 gallons per minute (gpm) or 25,920 gpd and represents continuous flow 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. 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

[4] Ground Water and Wellhead Protection Handbook, EPA/625/R-94/001, September, 1994
[5] http://www.epa.gov/WaterSense/pubs/indoor.html
[6] None of the wells in question have a water rights permit; therefore, this is the maximum amount that they would be allowed to pump.

for which a CZA was performed. The calculations, input values and final results are included in Excel spreadsheets *CaptureZoneCalculations_2017.xlxs* and *CaptureZoneCalculations_1000gpd_2017.xlxs*.

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.

Table 3 shows the results of the capture zone analyses. Calculations using the more realistic, but still conservative flow rate of 1,000 gpd did not result in any capture zones crossing an AE boundary. Under the second scenario, using the historic flow rate of 12 gpm (17,280 gpd) for well 41 (Chilson completion) resulted in a capture zone that extended upgradient 236 ft into the proposed AE area of Dewey wellfields 2 and 4 assuming the well is pumping continuously through 2017. The well has not been used for drinking water since at least 2006 when Powertech performed its well survey.

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. 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 upgradient 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 second 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 so wide it encompassed all of Burdock wellfield 10 and extended 1,273 feet into the proposed AE area of Burdock wellfield 8. The EPA determined that the flow rates used to calculate the second scenario are a large overestimation of the actual private well flow rates and are not reasonable. 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 continuously pump up to 4,650 gpd before the width of its capture zone extended crossgradient to reach the AE boundary of Burdock wellfield 10.

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. Inyan Kara groundwater requires treatment by reverse osmosis to decrease sulfate concentration below the secondary drinking water standards before is it palatable for human consumption. 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.

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.

Impacts of Expansion of AE Boundary on Private Well Capture Zones

As discussed in the above section in which the AE area is described, the AE boundary may shift outward after wellfield delineation drilling identifies the extent of the ore deposits in better detail. If the AE boundary encroaches on the capture zone of a private well, Powertech will perform another capture zone analysis. Powertech would use a computer flow model that would have the capability to simulate the impact of the intermittent pumping of a private well on the aquifer potentiometric surface. This approach would identify a more realistic capture zone. If the AE boundary encroaches on a capture zone after it has been recalculated using the more realistic flow model, Powertech is not authorized to expand the wellfield near the location of the private well capture zone.

Well #	Calculated distances (ft) using well flow rates in Tables 2 and 5		Calculated distances (ft) using 1,000 Gallons per Day		Distance from AE Boundaries (ft)
	Maximum Upgradient Capture Zone Extent	Maximum Width of the Capture Zone	Maximum Upgradient Capture Zone Extent	Maximum Width of the Capture Zone	
2	2,140’	3,655’	1,160’	141’	4,600’ downgradient from B-WF2
7	566’	2,460’	394’	402’	4,750’ crossgradient from B-WF2
8	5,492’	1,244’	5,269’	340’	9,625’ crossgradient from B-WF2
13	959’	299’	914’	207’	1,750’ downgradient from B-WF8
18	1,269’	3,917’	889’	340’	7,880’ downgradient from B-WF4
40	1,340’	2,074’	739’	144’	2,187.5’ crossgradient from D-WF2
41 (Fall River)	1,247’	1,076’	795’	62’	2,750’ downgradient from D-WF 3 3,300’ crossgradient from D-WF1
41 (Chilson)	3,236’	310’	2,924’	18’	3,000’ downgradient from D-WFs 2&4 3,300’ crossgradient from D-WF1
42	2,854’	909’	2,224’	35’	4,800’ downgradient from D-WF4
43	1,147’	4,873’	449’	188’	3,600 crossgradient from B-WF8 875’ crossgradient from B-WF10
704	2,854’	909’	2,224’	35’	4,800’ downgradient from D-WF4
4002	1,340’	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.

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 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 Dewey-Burdock project area: 1) the reduced zone, 2) the oxidized zone and 3) the ore deposit 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 upgradient 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 downgradient 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 upgradient from the ore deposit 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.

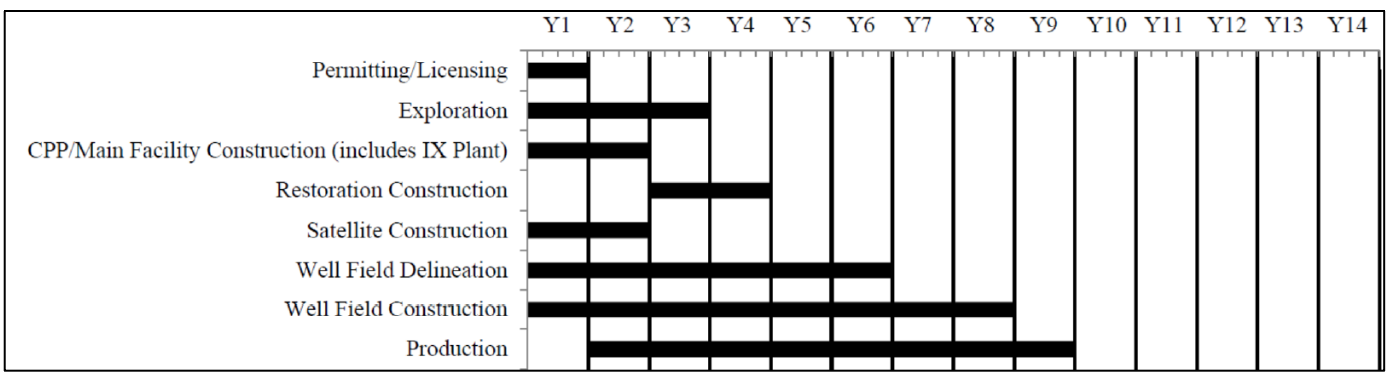
The ore deposit zone is located at the oxidation/reduction boundary where metals were precipitated when mineralizing solutions encountered an abrupt change from oxidizing conditions to reducing conditions as they moved down-gradient within the aquifers. Sandstones in this zone are greenish-black, black, 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 minerals (haggite and doloresite) are found adjacent to the uranium 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 upgradient, oxidized boundary of the ore deposit filling pore spaces between quartz grains. Molybdenum occurs as the mineral jordisite adjacent to the uranium on the downgradient, 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

The proposed time table for project development is shown in Figure 8. Powertech anticipates that the Dewey-Burdock uranium ore deposits will be commercially producible for nine years.

Figure 8. Powertech's Time Table for Project Development



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, including NRC license requirements and Class III Area Permit requirements, leading the EPA to the conclusion that adjacent USDWs will not be impacted by ISR contaminants crossing the AE boundary laterally or migrating vertically.

The NRC license requires Powertech to conduct groundwater restoration after uranium recovery has been completed in a wellfield. Groundwater restoration must continue until ISR contaminant concentrations are at or below Commission approved background concentrations that reflect pre-ISR concentrations. If neither the Commission Approved Background nor drinking water standards can be achieved for an ISR contaminant, then Powertech will submit to the NRC an application for approval of an alternate concentration limit (ACL), which is an amendment to the license. The NRC will not approve an ACL unless Powertech demonstrates the ACL is protective of human health and the environment.

After groundwater restoration is completed for a wellfield, Powertech must conduct stability monitoring to determine that restored concentrations of ISR contaminants are chemically stable and will not rebound or increase in concentration over time. The NRC license requires that stability monitoring be conducted until the data show that the ISR contaminant concentrations for the most recent four consecutive quarters indicate no statistically significant increasing trend. If a constituent does not meet the stability criteria, Powertech must take appropriate actions to remedy the situation. Potential actions may include extending the stability monitoring period or returning the wellfield to a previous phase of active restoration until Powertech can demonstrate the chemical instability issue is resolved. If the analytical results from the stability period continue to meet the NRC license Commission Approved Background and meet the stability criteria, Powertech will submit supporting documentation to the NRC showing that the restoration parameters have remained at or below the restoration standards and request that the wellfield be declared restored.

The Class III Area Permit includes the following 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.

- Powertech is required to develop a geochemical model to evaluate the long-term stability of restored ISR contaminant concentrations to ensure that no ISR contaminants cross the AE boundary. The geochemical model must be calibrated using field data collected during groundwater restoration monitoring and stability monitoring. If the model shows there is a high probability that a restored ISR contaminant concentration will rebound or increase in concentration above the Commission Approved Background concentration, Powertech must conduct mitigation measures to stabilize that ISR contaminant.
- If Powertech requests a modification of its license from the NRC for approval of an ACL as the target groundwater restoration concentration for one or more ISR contaminants, Powertech must update the geochemical model to evaluate the potential of the ISR contaminants with approved ACLs to cross the AE boundary and take remedial action if the model shows it is likely an ISR contaminant will cross the AE boundary above its baseline concentration.

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: 5.3896E-09 cm/sec, compared with the vertical hydraulic conductivity of the Chilson Sandstone, 1.3474E-03 cm/sec or Fall River Formation sandstone, 4.7659E-04 cm/sec.

As shown in Figure 9, 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 10. 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 10.

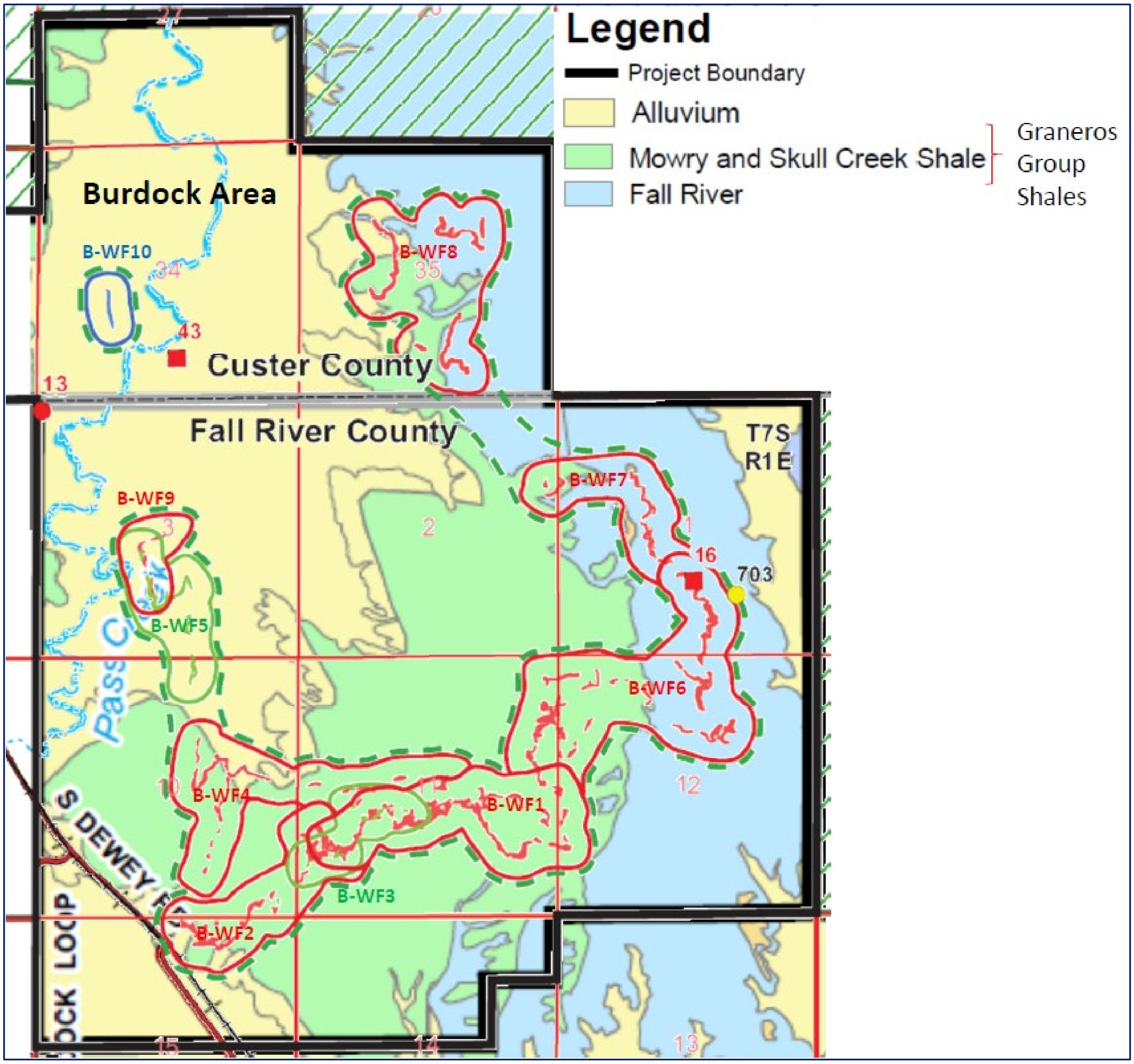


Figure 9. Map Showing Surface Geology of the Burdock Area and Burdock Area Wellfields.

Figure 10 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 10 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 6.1595E-09 to 1.7555E-07 cm/sec.

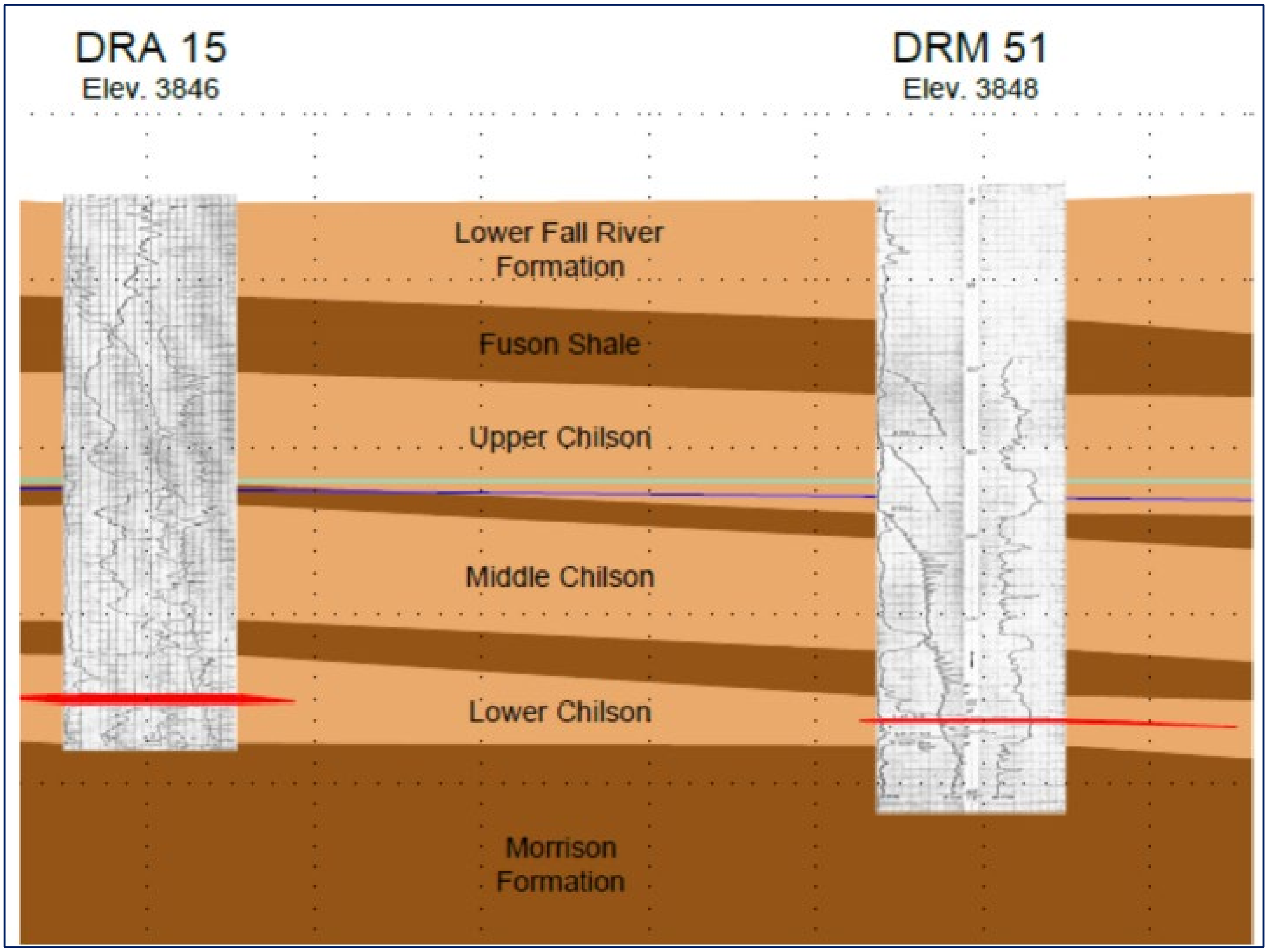


Figure 10. Portion of Cross Section B-B' from Plate 6.14 of the UIC Class III Permit Application.

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 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 x 10-9 to 4.2 x 10-8 cm/sec. 6

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 7. 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.

DRAFT

____________________________________ _______________________

Sarah Bahrman, Chief
Safe Drinking Water Branch

Date

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 upgradient 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 upgradient extent of each capture zone using both scenarios for flow rate. Table 3 also shows the distance each well is located downgradient from an AE boundary. So as not to call into question the exact downgradient flow direction upgradient 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 upgradient 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 upgradient extent and the width of the capture zone.

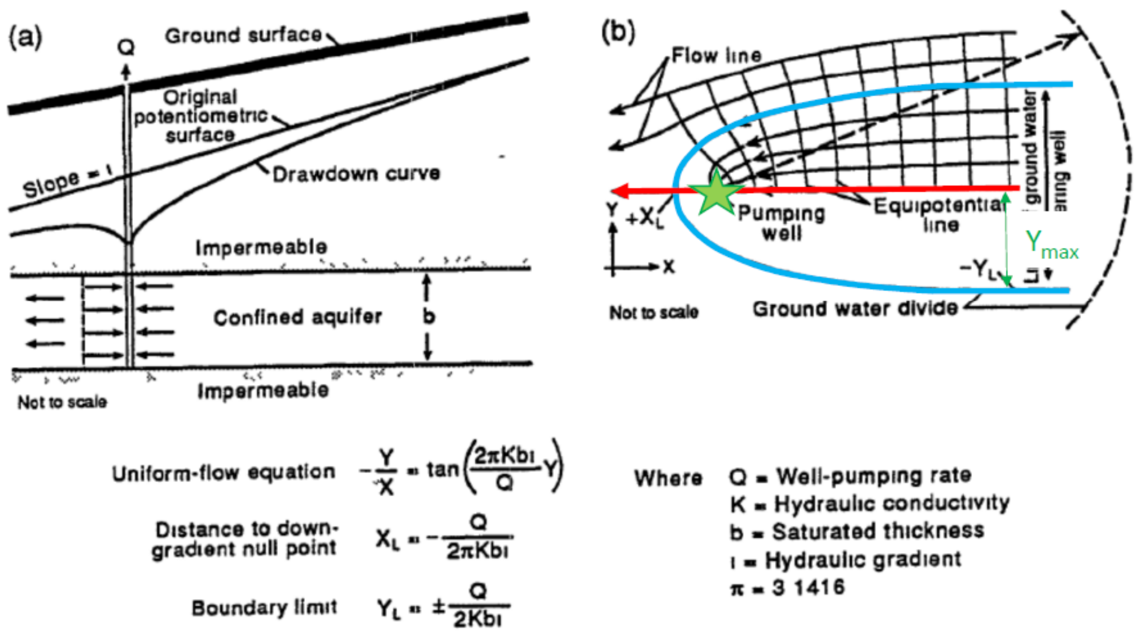
Well ID#	Sec,Township Range	Screened Interval & Project Site Area	Distance & Direction from Aquifer Exemption Boundary	Year Constructed/# Years & Days of Operation to 2017	Historic Values for Flow rate gpm
2	SESE Sec 16 T7S R1E	Chilson Burdock	4,600’ downgradient from B-WF2	1930s, Use 1930 32,142 days	30 gpm which is greater than the SEO allows without water rights permit Use 18 gpm / 25,920 gpd
7	NWNW Sec 23 7S 1E	Fall River Burdock	4,750’ crossgradient from B-WF2	Late 1950s, Use 1958 21,915 days	4.25 gpm 6,120 gpd
8	SWSE Sec 23 23 7S 1E	Fall River Burdock	9,625’ crossgradient from B-WF2	Well repair form 1951. Casing had corroded away. Assume original well drilled in 1930 32,142 days	2.5 gpm 3,600 gpd
13	NWNW Sec 3 T7S R1E	Chilson Burdock	1,750’ downgradient from B-WF10	1950s, Use 1950 24,837 days	Notice of well construction says well flows at 1 gpm, 1,440 gpd
18	SWSW Sec 9 T7S R1E	Fall River Burdock	7,880’ downgradient from B-WF4	Late 1920s to early 1930s Use 1930 32,142 days	8 gpm 11,520 gpd
40	SWNW Sec 30 T6S R1E	Inyan Kara Dewey	2,187.5’ crossgradient from D-WF2	1969 17,897.25 days	2 gpm 2,880 gpd
41	SWNE Sec 31 T6S R1E	Fall River Dewey	2,750’ downgradient From D-WF3 3,300’ crossgradient from D-WF1	No information Use 1930; 32,142 days	12 gpm 17,280 gpd
41	SWNE Sec 31 T6S R1E	Chilson Dewey	3,000’ downgradient From D-WFs 2&4 3,300’ crossgradient from D-WF1	No information Use 1930; 32,142 days	12 gpm 17,280 gpd
42	SWNE Sec 5 T7S 1E	Chilson Dewey	4,800’ downgradient From D-WF4	1949 25,202.25 days	Flows 30 gpm, Use 18 gpm 25,920 gpd
43	SWSE Sec 34 T6S R1E	Chilson Burdock	3,600’ crossgradient from B-WF8 875’ crossgradient from B-WF10	No information Use 1930; 32,142 days	No info Use 18 gpm 25,920 gpd
704	SWNE Sec 5 T7S 1E	Chilson Dewey	4,800’ downgradient From D-WF4	2008 3,652.5 days	No info Use 18 gpm 25,920 gpd
4002	NWSW Sec 30 T6S R1E	Inyan Kara Dewey	2,125’ crossgradient from D-WF2	1940s Use 1940 28,489.5 days	No info Use 18 gpm 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 2017 (days)	Flow Rate (gpd)
2	SESE 16 T7S R1E	Chilson Burdock	150 & 190	0.296 & 0.319	0.00316	63	32,142	25,920 & 1,000
7	NWNW Sec 23 7S 1E	Fall River Burdock	54 & 255	0.29	0.00308	186	21,915	6,120 & 1,000
8	SWSE Sec 23 23 7S 1E	Fall River Burdock	54 & 255	0.29	0.00364	20	32,142	3,600 & 1,000
13	NWNW 3 T7S R1E	Chilson Burdock	150 & 190	0.296 & 0.319	0.00215	45	24,837	1,440 & 1,000
18	SWSW 9 T7S R1E	Fall River Burdock	54 & 255	0.29	0.00364	128	32,142	11,520 & 1,000
40	SWNW 30 T6S R1E	Inyan Kara Dewey	255	0.29	0.00364	150	17,897.25	2,880 & 1,000
41	SWNE Sec 31 T6S R1E	Fall River Dewey	255	0.29	0.00421	165	32,142	17,280 & 1,000
41	SWNE Sec 31 T6S R1E	Chilson Dewey	590	0.296 & 0.319	0.00631	140	32,142	17,280 & 1,000
42	SWNE 5 7S 1E	Chilson Dewey	590	0.296 & 0.319	0.00646	150	25,202.25	25,920 & 1,000
43	SWSE 34 T6S R1E	Chilson Burdock	150 & 190	0.296 & 0.319	0.00237	145	32,142	25,920 & 1,000
704	SWNE 5 7S 1E	Chilson Dewey	590	0.296 & 0.319	0.00646	150	3,652.50	25,920 & 1,000
4002	NWSW 30 T6S R1E	Inyan Kara Dewey	255	0.29	0.00364	150	28,489.5	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.