Corrective Measures Assessment

Ash Pond - Dave Johnston Power Plant
Glenrock, Wyoming

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ACRONYMS

AACE	Advancement of Cost Engineering
bgs	Below Ground Surface
BLM	Bureau of Land Management
BMP	Best Management Practice
CCR	Coal Combustion Residuals
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EPA	U.S. Environmental Protection Agency
FGD	Flue-Gas Desulfurization
GCL	Geosynthetic Clay Liner
ft/day	Feet/day
MCL	National Public Water Supply - Maximum Concentration Limit
MNA	Monitored Natural Attenuation
RCRA	Resource Conservation and Recovery Act
RPB	Reactive Permeable Barrier
TDS	Total Dissolved Solids
USFS	U.S. Forest Service
WDEQ	Wyoming Department of Environmental Quality
WET	Water & Environmental Technologies

1.0 PURPOSE & SCOPE

This report provides the findings of an investigation to determine the nature and extent of the release and an assessment of corrective measures for the Ash Pond, a Coal Combustion Residual (CCR) unit at the Dave Johnston Power Plant near Glenrock, Wyoming. It was prepared for PacifiCorp by Water and Environmental Technologies (WET) to comply with the requirements detailed in *Code of Federal Regulations* (CFR) § 257.95(g)(1) and 257.96 (*Final Rule*).

Detection monitoring was conducted between September 2015 and September 2016. The results of detection monitoring revealed statistically significant levels above background for all Appendix III constituents except boron and TDS.

As a result, the CCR Ash Pond monitoring program was transitioned to assessment monitoring in 2018. The results of two rounds of sampling completed between February and May of 2018, revealed Appendix IV constituents – arsenic, cadmium, molybdenum and radium were at statistically significant levels above the groundwater protection standards established for the CCR Landfill.

CFR § 257.95(g)(1) requires the owner of a CCR unit in which one or more constituents in Appendix IV are detected at statistically significant levels above the site-specific groundwater protection standards, to characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected. CFR § 257.95(g)(3)(i) requires the owner of a CCR unit to conduct an assessment of corrective measures as required by 257.96. In compliance with these requirements, PacifiCorp conducted, in parallel, an investigation to assess the nature and extent of the release and an assessment of corrective measures for the Ash Pond.

1.1 Organization

This report is organized to address the requirements of CFR § 257.95 and CFR § 257.96 under the Final Rule as follows:

- Site Background & History
- Nature & Extent of Release
- Assessment of Corrective Measures
- Reporting

2.0 SITE BACKGROUND & HISTORY

The Dave Johnston Power Plant is located 6.6 miles southeast of Glenrock, Wyoming. The physical location is Township 33 North, Range 74 West in Converse County. The facility is a four-unit coal-fired electrical generation plant owned by PacifiCorp. The facility Ash Pond was constructed in 1971 to accommodate additional ash production from Unit 4. Bottom ash is slurried to the Ash Pond and spent flue gas de-sulfurization (FGD) scrubber fluids are transported there during upset conditions at the plant. As a result, the Ash Pond is considered a coal combustion residual (CCR) unit (Figure 1).

A 1992 Study identified the Ash Pond as a potential source of releases to groundwater. A liner system was installed in the pond (1992 – 1995) to reduce / prevent CCR waste in the Ash Pond from impacting area groundwater. Ongoing groundwater monitoring after the liner system was installed, as required by the Wyoming Department of Environmental Quality (WDEQ), determined the liner was successful in reducing contaminant loading in the upper aquifer following its installation. Recent groundwater monitoring suggests the Ash Pond may be impacting groundwater. WDEQ is requiring Ash Pond closure of the Ash Pond which includes removal of all CCR waste. While this closure will be conducted to meet WDEQ regulations, it will also be completed in accordance with the *Final Rule*. Additional detail on previous studies can be found in Section 2.7 of this report.

2.1 Site Conceptual Model

The site conceptual model for the Dave Johnston Power Plant was developed to summarize site information currently available and provide the background information needed to assess corrective measures for the site. As defined in Section 2 of this report, considerable historic information and environmental data are available to characterize site conditions. These data have been collected, evaluated and organized into the conceptual site model described below.

2.2 Physiography

The Dave Johnston Power Plant is located in a rural area on the high, arid plains of east-central Wyoming. The community of Glenrock, population 2,576, is located approximately 6.6 miles northwest of the plant. Other regional metropolitan areas include the communities of Casper (pop. 49,644) and Douglas (pop. 5,288). The region is rich in coal, natural gas, and mineral deposits which have undergone exploration and extraction since the 1890s. Non-industrial private lands in the area support cattle and sheep ranches, with large units of Bureau of Land Management (BLM) and U.S Forest Service (USFS) lands distributed throughout the regional landscape that support cattle grazing, oil and gas development, and mining.

The climate in east-central Wyoming, can generally be classified as semiarid, dry and cooldue to the effective barrier to moisture from the Pacific Ocean offered by the Cascade and Sierra Nevada ranges. The Wyoming State Climate Office identified Wyoming as the fifth driest state in the country, (Wenck 2016). The average annual high temperature is 68°F and the average low is 25°F. The average annual precipitation for the area is approximately 12 inches and evaporation significantly exceeds precipitation. Summer precipitation is almost exclusively from thunder shower activity and under normal conditions provides sufficient moisture to maintain growth of rangeland grasses. Annual snowfall averages 78 inches (BLM 2006).

Vegetation in the region is predominantly grassland and sagebrush/grassland. The grassland is found in well-drained upland areas on ridge tops and flat areas, with blue grama, thread leaf sedge, and needle-and-thread as the dominant perennial grasses. The sagebrush/grassland is found on sloped areas and drainages. Shrub cover varies with big sagebrush on sloped areas to silver sagebrush in drainages and at the toe of slopes (BLM 2006).

Pronghorn antelope and mule deer are widespread throughout this region of Wyoming. Other predominant wildlife resources include white-tail deer, red fox, coyote, and cottontail rabbits. Large bird species include: bald eagles, ferruginous hawks, red-tailed hawks, golden eagles, great horned owl and sage grouse (BLM 2006).

2.3 Surface Water

The North Platte River flows along the southern boundary of the Dave Johnston Power Plant, and drains to the east / northeast through Wyoming, before turning southeast to its confluence with the South Platte in Nebraska. The Platte River Basin is the "economic and ecological life blood of much of the mid-continental United States" (Wenck 2016) and the most densely populated major watershed in Wyoming. The Platte River is a major tributary to the Missouri River whose confluence with the Platte occurs along the eastern Nebraska border. The North Platte serves as a water supply to the Dave Johnston Plant. The North Platte also provides recreational opportunities and irrigation water for area agricultural enterprises. The Platte River Basin is also one of the most regulated basins in Wyoming. In 1945, the US Supreme Court apportioned the North Platte water supplies between Wyoming and Nebraska in the *North Platte Decree*. The decree was re-opened in 1986 and modifications to the decree were finalized in the *2001 Modified North Platte Decree*.

2.4 Geology

Due to uplift of the mountains to the west and increased precipitation, the North Platte River was a degrading stream during the early and middle Pleistocene. This activity scoured into the Lance shale and left behind classic fining-upward alluvial sequences. These sequences include channel deposits, abandoned channels, braided channels, floodplain deposits and oxbow lakes (Rapp, 1953).

The surface topography of the bedrock was modified by the various erosional and depositional stages of the North Platte River (Figure 2). On top of the bedrock, the river has deposited a classic alluvial sequence of upward fining sediments (Qal-np). The degree of sorting within the alluvial deposit is dependent on the stage of the river. During the early Pleistocene, deposition occurred under high-energy conditions resulting in a poorly sorted deposit. Lower energy meandering of the river during the middle to late Pleistocene resulted in a deposit that is well sorted with visible contacts between depositional sequences. During previous investigations, continuous core sampling provided detailed descriptions and locations of the deposits and allowed a much better understanding of the geologic controls on the site hydrogeology (Atlatl, 1996).

Aeolian deposits (Qal-a) are common on the surface along the northern site border. However, the windblown sand, characterized by frosted sand grains, has been reworked and deposited in an alluvial (well sorted) sand sequence. In addition, Sand Creek has formed an alluvial deposit (Qal-sc) which dissects the site from north to south and forms a subsurface channel of outwash sand and gravel. Well logs and water chemistry data, indicate the Sand Creek channel overlays the Lance shale at the Dave Johnston Plant. Well logs for the detection monitoring network are included in the site-specific sampling and analysis plan for the Ash Pond, which is part of the facility operating record (WET, 2017).

The alluvial units are underlain by the upper Cretaceous Lance Formation. This formation is composed of shale and sandstone in the study area. The top several feet of the Lance has weathered into a clay or silt material. The irregular topography of the Lance has been formed by the interaction of erosional activity of the North Platte River and the variability in consolidation in the Lance Formation. The geometry of floodplain and meander channel deposits are key to understanding groundwater flow at this site. The more permeable channel material transports the majority of groundwater across the site from northwest to south, southeast.

2.5 Hydrogeology

Site hydrogeology is complex, due mainly to the bedrock topography at the site. While groundwater flow direction and gradient does fluctuate; in general, the flow direction follows the topography of the bedrock, much the same as surface water.

The alluvial aquifer is unconfined to semi-confined and underlain by the less permeable Lance shale (Table 1). Near the Ash Pond, it varies in thickness from 18 feet to greater than 47 feet and the subsurface depth to water varies from 10 feet to 20 feet below ground surface (bgs). Recent slug testing indicates the hydraulic conductivity of the alluvium ranges from approximately 1.5 to 11 feet/day (ft/day) with a geometric mean conductivity of 3.1 ft/day. Per Morris and Johnson, 1967 (in Kresic N. 2007) data on properties of rock and soil, site-specific aquifer porosity and effective porosity are 37% and 27%, respectively.

The groundwater flow direction in the vicinity of the Ash Pond is to the southeast with a hydraulic gradient of approximately 3.5×10^{-4} to 5.1×10^{-3} feet/feet (Figure 3). The groundwater flow velocity ranges from approximately 0.004 ft/day to 0.059 ft/day.

2.6 Aquifer Resource Value

The Ash Pond at the Dave Johnston Power Plant is underlain by Quaternary alluvium. The alluvial deposits in this area, while minor in extent, have relatively good water quality; varying between Class I and II waters in the site background wells. Yields in the alluvium may be significant near perennial streams and the North Platte River, but many of the shallow aquifers with hydraulic connection to surface water are unavailable for development due to limitations on water from “hydrologically connected groundwater wells” in the 2001 Modified North Platte Decree.

Areas where groundwater is not considered hydrologically connected have been defined as “green areas” on maps developed by the Wyoming Sate Engineers Office. The Dave Johnston plant site falls mostly within the “green area” with the exception of the southernmost part of the plant site that is near the North Platte River.

Table 1. Dave Johnston Power Plant - Slug Test Results

<table>
<tr><td rowspan="4">Calculated Hydraulic Conductivity</td><td>DJ-2</td><td>DJ-12R</td><td>DJ-33</td></tr>
<tr><td rowspan="2">5.5E-04</td><td>4.0E-03</td><td>4.4E-04</td></tr>
<tr><td>3.9E-03</td><td rowspan="2">6.7E-04</td></tr>
<tr><td>5.1E-04</td><td>3.7E-03</td></tr>
<tr><td># of Measurements:</td><td>2</td><td>3</td><td>2</td></tr>
<tr><td>Mean Conductivity (cm/sec):</td><td>5.4E-04</td><td>3.9E-03</td><td>6.4E-04</td></tr>
<tr><td>Mean Conductivity (ft/day):</td><td>1.5</td><td>11</td><td>1.8</td></tr>
</table>

The alluvium is underlain by the Lance shale which generally has higher TDS, sulfate and salt concentrations than the overlying alluvium. The Lance Formation has a lower permeability as indicated by the aquifer testing results shown in Table 1. Hydraulic conductivities in the shale vary from 1 ft/day to 2 ft/day versus greater than 10 ft/d in the alluvial material. Although limited in quantity, water quality in the alluvium is good (Class I, TDS < 500 mg/L) and wells can be prolific near the perennial surface water sources. The Lance shale wells have poorer quality and use of the water can be limited without treatment.

At this arid, high desert site, alternate water supplies are scarce (Figure 4). This map shows all points of diversion within 5 miles of the plant on a geologic map. Most points of diversions are located within the Quaternary alluvium along perennial streams.

2.7 Previous Investigations

The Dave Johnston Power Plant is undergoing groundwater monitoring under two separate programs, one mandated by the Wyoming Department of Environmental Quality (WDEQ) to satisfy RCRA requirements, and the second to address the requirements detailed in the CCR *Final Rule*. WDEQ monitoring began in the 1970s and continues to the present, generally under a semi-annual program. CCR monitoring was initiated in 2015 and continues to the present. In addition, several site-specific geotechnical and environmental investigations have been completed, with an emphasis on hydrogeologic and environmental conditions. The reports directly related to the Ash Ponds are discussed below.

2.7.1 EPA Investigation - 1981

The 1981 study (published 1985) included 14 test borings of which, 12 were converted to monitoring wells. The purpose of this study was to supplement a nationwide U.S. Environmental Protection Agency (EPA) effort, to evaluate potential impacts on groundwater from fly ash disposal at coal fired power plants. The study provided detailed hydrogeologic information for the east side of Sand Creek, while concluding the Dave Johnston Power Plant did not negatively impact groundwater in the study area.

2.7.2 Baseline Conditions Investigation - 1992

The 1992 study compiled data and findings from previous Dave Johnston studies, with a supplemental site-specific investigation. The investigation sought to further characterize hydrogeologic and environmental conditions sitewide, while performing an assessment of baseline groundwater conditions prior to construction of the landfill and subsequent acceptance of waste (July 1993). The results are included in the ongoing state mandated monitoring reports and were used to supplement this assessment.

The report summarized statistical analyses performed on existing data to augment the understanding of groundwater quality across the Dave Johnston facility. By comparing downgradient water quality with upgradient well data, the analysis determined the distribution of the data sets, and identified observed trends in the data through 1992. The statistical analysis identified that downgradient sulfate concentrations exceeded upgradient concentrations near the Ash Pond. To address the identified sulfate impacts to groundwater, a liner system was installed in the pond (1992 – 1995) to reduce / prevent CCR waste in the Ash Pond from impacting area groundwater.

2.7.3 Ongoing Groundwater Monitoring and Reporting

WDEQ requires semiannual groundwater monitoring throughout the site including up and downgradient of the Ash Pond. The results of the monitoring are evaluated, and a report is submitted to WDEQ annually. Groundwater monitoring after the liner system was installed determined the liner was successful in reducing contaminant loading in the upper aquifer following its installation. Ongoing monitoring continued to show decreased concentrations in the groundwater most likely due to natural attenuation, however, the2018 and 2019 groundwater monitoring results indicate the Ash Pond may be leaking resulting in impacts to the groundwater on the facility.

2.7.4 CCR Monitoring

Between 2015 and 2017, initial detection monitoring was conducted at the Ash Pond to comply with the CCR *Final Rule*. This monitoring effort included monthly and semi-annual monitoring of new and existing wells to support a determination of whether any CCR-specified Appendix III constituents exceed background. Results from detection monitoring revealed all Appendix III constituents except boron and TDS exceeded site-specific background concentrations. Based on these findings, the Ash Pond was transitioned to assessment monitoring in 2018.

In accordance with the *Final Rule*, assessment monitoring was initiated at the Ash Pond in February of 2018. Two sampling events were completed, and statistical analysis was performed, groundwater protection standards were adopted, and downgradient water quality was examined.

This effort revealed Appendix IV constituents: arsenic, cadmium, molybdenum, and radium exceeded the groundwater protection standards established for the Ash Pond (Table 2).

Table 2. Summary of Groundwater Quality Comparisons – Assessment Monitoring

Analyte	Upper Tolerance Limit (mg/L)	Maximum Contaminant Level (mg/L)	Groundwater Protection Standard (mg/L)	Downgradient Wells Exceeding the Groundwater Protection Standard
Antimony	0.001	0.006	0.006	None Exceed
Arsenic	0.012	0.010	0.012	DJ-35
Barium	1.2	2	2	None Exceed
Beryllium	0.004	0.004	0.004	None Exceed
Cadmium	0.003	0.005	0.005	DJ-36
Chromium	0.06	0.1	0.1	None Exceed
Cobalt	0.12	0.006	0.12	None Exceed
Fluoride	0.8	4	4	None Exceed
Lead	0.06	0.02	0.06	None Exceed
Lithium	0.1	0.040	0.1	None Exceed
Mercury	0.0001	0.002	0.002	None Exceed
Molybdenum	0.045	0.100	0.100	DJ-33, DJ-35
Radium	6.8	5	6.8	DJ-36
Selenium	0.01	0.05	0.05	None Exceed
Thallium	0.0005	0.002	0.002	None Exceed

3.0 NATURE & EXTENT OF RELEASE

The following section describes the nature of the release at the Dave Johnston Power Plant and defines the extent of the resulting groundwater plume.

3.1 Nature of Release

The Ash Pond was constructed in 1971 to accommodate additional ash production at the plant. Bottom ash is slurried to the Ash Pond as part of regular operations. Spent FGD scrubber fluids are transported to the Ash Pond during upset conditions at the plant. To assess contaminant source material, samples were collected from the surface of the Ash Pond (decant water) as well as from monitoring wells at the boundary of the Ash Pond (DJ-36). These results are provided in Table 3. It should be noted that while the decant water data originated from the surface of the Ash Pond, the decant water is pond surface water, and does not likely fully represent the constituents that have leaked from the pond, as the decant water has not infiltrated the ash and FGD solids prior to being sampled.

Table 3. Nature & Extent Sampling Results – Source Material

Sample Location:	Analyte:	Result:	Units:
DJ-36	Antimony	ND	mg/L
	Arsenic	0.006	mg/L
	Barium	0.18	mg/L
	Beryllium	ND	mg/L
	Boron	1.4	mg/L
	Cadmium	0.011	mg/L
	Calcium	140	mg/L
	Chloride	29	mg/L
	Chromium	0.016	mg/L
	Cobalt	0.080	mg/L
	Fluoride	1.4	mg/L
	Lead	0.015	mg/L
	Lithium	ND	mg/L
	Molybdenum	0.034	mg/L
	pH	7.82	s.u.
	Radium	6.0	pCi/L
	Selenium	ND	mg/L
	Sulfate	555	mg/L
	TDS	1,040	mg/L
	Thallium	ND	mg/L
Ash Pond Decant Water	Antimony	0.003	mg/L
	Arsenic	0.001	mg/L
	Barium	0.17	mg/L
	Beryllium	ND	mg/L
	Boron	0.09	mg/L
	Cadmium	ND	mg/L
	Calcium	75	mg/L
	Chloride	19	mg/L
	Chromium	0.004	mg/L
	Cobalt	ND	mg/L
	Fluoride	0.3	mg/L
	Lead	ND	mg/L
	Lithium	ND	mg/L
	Molybdenum	0.006	mg/L
	pH	8.87	s.u.
	Selenium	0.003	mg/L
	Sulfate	217	mg/L
	TDS	516	mg/L
	Thallium	ND	mg/L

Thus, the monitoring data from the Ash Pond boundary wells, although diluted by groundwater, likely provides a better indication of the source of impacts to groundwater at the facility. For comparison and analysis purposes, the results for both the decant water and the DJ-36 monitoring well are provided in Table 3.

3.2 Extent of Release

As noted, groundwater recharge at the site comes primarily from the North Platte River above the dam and from groundwater flowing along a paleochannel of the North Platte River. As a result of large storm events, occasional infiltration also occurs along the Sand Creek alluvium. The majority of the groundwater discharges to the southeast of the Ash Pond, however, a component of groundwater also flows to the east from the Ash Pond across the northern interior of the site, discharging to the northeast of the Expansion Landfill (Figure 3).

This component of flow to the east of the Ash Pond provides a pathway for constituents released from the Ash Pond to migrate east and impact groundwater quality to the east / northeast. To bound the lateral extent of the groundwater plume, two additional wells were installed in October of 2018: DJ-48 and DJ-49. They were placed along the extreme eastern boundary of the Dave Johnston facility to determine if groundwater impacts had reached this location and/or migrated beyond the facility boundary. Results from the October sampling event indicate DJ-48 and DJ-49 provide lateral bounding of the plume, with all Appendix IV constituents below the groundwater protection standards for the Ash Pond (Table 4). An iso-concentration map showing the extent of the Appendix IV constituents exceeding groundwater protection standards is provided in Figure 5.

Table 4. Nature & Extent Sampling Results – Plant Boundary Wells

Sample Location:	Analyte:	Result:	Units:
DJ-48	Antimony	ND	mg/L
	Arsenic	ND	mg/L
	Barium	0.12	mg/L
	Beryllium	ND	mg/L
	Boron	0.08	mg/L
	Cadmium	ND	mg/L
	Calcium	40	mg/L
	Chloride	1	mg/L
	Chromium	0.004	mg/L
	Cobalt	ND	mg/L
	Fluoride	0.5	mg/L
	Lead	0.003	mg/L
	Lithium	ND	mg/L
	Mercury	ND	mg/L
	Molybdenum	0.003	mg/L
	pH	7.83	s.u.

Sample Location:	Analyte:	Result:	Units:
	Radium 226 + Radium 228	1.1	pCi/L
	Selenium	ND	mg/L
	Sulfate	27	mg/L
	TDS	291	mg/L
	Thallium	ND	mg/L
DJ-49	Antimony	0.003	mg/L
	Arsenic	0.001	mg/L
	Barium	0.1	mg/L
	Beryllium	ND	mg/L
	Boron	0.09	mg/L
	Cadmium	ND	mg/L
	Calcium	48	mg/L
	Chloride	4	mg/L
	Chromium	0.002	mg/L
	Cobalt	ND	mg/L
	Fluoride	0.2	mg/L
	Lead	0.001	mg/L
	Lithium	ND	mg/L
	Mercury	ND	mg/L
	Molybdenum	0.008	mg/L
	pH	7.96	s.u.
	Radium 226 + Radium 228	0.9	pCi/L
	Selenium	ND	mg/L
	Sulfate	47	mg/L
	TDS	284	mg/L
	Thallium	ND	mg/L

The groundwater monitoring data compiled in the 1992 report identified downgradient sulfate concentrations exceeded up-gradient concentrations near the Ash Pond. To address the identified sulfate impacts to groundwater, a liner system was installed in the pond to reduce / prevent CCR waste in the Ash Pond from impacting area groundwater. Groundwater monitoring after the liner system was installed demonstrated that the liner was successful in reducing contaminant loading in the upper aquifer following its installation. Ongoing monitoring from 1992 through 2016 continued to show decreased concentrations in the groundwater most likely due to natural attenuation. However, the 2017 and 2018 groundwater monitoring results indicated new seepage resulting in potential impacts to the groundwater on the facility. The CCR assessment monitoring confirmed the presence of groundwater impacts. In spite of the identified leakage, the seepage from the pond is contained on the property and does not pose an immediate risk to human health or the environment. The pond will be closed the fall of 2019, by removing all CCR material and as much impacted soil as feasible. This will eliminate all ongoing contamination or seepage into the groundwater. The evaluation of correctives measures presented in Section 4 has the closure by removal as the baseline alternative and addresses the residual impacts to groundwater presented above in the remainder of the options in Section 4.

Providing an estimate of the quantity of material released from the CCR unit is required under §257.95(g)(1)(ii). The best available data to estimate the quantity of Appendix IV constituents released from the unit to the groundwater is to utilize concentrations found in the groundwater as depicted in the iso-contour map (Figure 5) and an estimated volume of the aquifer. The volume of the aquifer was calculated by estimating the depth of the aquifer from site wells logs and estimating the aerial extent of the impacted groundwater from the monitoring data. The effective porosity of the aquifer determined during aquifer testing was then used to calculate the volume of water within the pore space of the aquifer material.

The concentrations were estimated as a gradient across the aquifer. The background concentration for each constituent was subtracted from the concentration detected in the downgradient wells. The volume was then multiplied by the concentration and converted to pounds to estimate the quantities of Appendix IV constituents released to the environment as dissolved compounds. An estimate of each Appendix IV constituent that exceeded the Groundwater Protection Standard was calculated except for radium. [1] The estimate quantities are only approximations due to the different geochemical characteristics of each analyte: absorption, dispersion and attenuation (i.e. some metals readily react, degrade or adsorb to the aquifer matrix, while other compounds are conservative and remain in solution).

Parameters that exceed groundwater protection standards at Dave Johnston Power Plant are arsenic, cadmium, molybdenum and radium. The mass detectable in the aquifer, based on current data for each of these constituents is: arsenic - 0.042 lbs.; cadmium - 0.016 lbs.; and molybdenum - 0.408 lbs.

3.3 Potential Risks to Human Health & Environment

Constituents of potential concern (COPCs) found in groundwater at the Dave Johnston Power Plant, include those Appendix IV constituents that exceed health-based guidelines (MCLs) established under the *National Primary Drinking Water Regulations* and/or updates to the *Final* Rule issued in July 2018. These constituents include – arsenic, cadmium, molybdenum, and radium. Human health effects associated with these constituents are as follows (ATSDR 2019):

- Arsenic: cancer, blood, skin
- Cadmium: lungs, kidney
- Molybdenum: kidney, liver, lungs
- Radium: blood, eyes, bone cancer

[1] Mass of radium was not calculated as reported values measure activity, which is not a measurement of mass but the rate of radioactive decay occurring.

During CCR monitoring, chemicals that exceeded either site-specific background concentrations or groundwater protection standards are outlined in Section 2.7.4. The mean concentrations for wells exhibiting the highest concentrations are provided in Table 5. Their corresponding background concentrations are also included. The results illustrate that contributions from Dave Johnston Plan operations represent, in most cases, incremental increases in groundwater concentrations when compared with naturally occurring levels in facility groundwater.

Table 5. Mean versus Background Concentrations

Analyte	Well Id#	Mean Concentration (mg/L)	Background Concentration (mg/L)
Fluoride	DJ-35	221	0.8
Arsenic	DJ-35	0.006	0.012
Cadmium	DJ-36	0.004	0.003
Molybdenum	DJ-33	0.114	0.045
Radium	DJ-36	4.43	6.8

In order for COPCs to pose a risk to human health or environmental risk, complete exposure pathways must be present, whereby human or environmental receptors regularly come into contact with elevated concentrations of the COPCs. The main potential exposure routes for the Ash Pond include:

1. Dermal exposure and possible ingestion of groundwater from impacted water supply wells.
2. Release of impacted waters to the North Platte River.
3. Worker dermal exposure and possible ingestion during environmental sampling of impacted waters.

Water Supply Wells. Trace concentrations of these COPCs are confined to groundwater within the plant footprint. Groundwater from the plant is used as a potable source for plant workers. However, the potable water wells are completed at depths between 600 and 650 feet below ground surface. The wells are sampled periodically to determine if water quality is acceptable for human consumption. These results indicate the water is of sufficient quality for these uses, with all chemical-specific parameters below primary and secondary drinking water standards. The data from the wells suggest there is no contact between the impacted uppermost aquifer and the deeper aquifer tapped for potable water wells. As a result, consumption of potable water from plant wells does not pose a risk to human health.

North Platte River. Human receptors that could be impacted by releases from the Ash Pond include potable water, irrigation and recreational users of the North Platte River. Concentrations of CCR-mandated constituents (Appendix III and IV), while above site-specific background or maximum contaminant levels (MCLs) at the Ash Pond, are relatively low and decrease as groundwater migrates across the plant. Figure 5 indicates that exceedances in groundwater are bounded by the monitoring network and Figure 3 indicates that groundwater flow is to the east-southeast away from the North Platte River.

Worker Contact. Worker contact with groundwater is currently limited to environmental sampling and construction workers when pond removal / closure begins. Safety precautions are in place to limit dermal exposure of environmental samplers (gloves, safety glasses). These practices reduce the likely exposures to impacted groundwater. Worker exposure to groundwater and impacted solid media during the planned closure of the Ash Pond, will require a health and safety plan and best management practices to ensure worker exposure is minimized (dust suppression, groundwater management). With proper planning, potential exposures should be reduced to safe levels.

The *Final Rule* also mandates an examination of potential damage to wildlife, crops / vegetation, and physical structures should the implementation of remedies take substantial time. The EPA National Recommended Aquatic Life listing contains the most up to date criteria for water quality pertaining to aquatic life. EPA defines aquatic life criteria for toxic chemicals as "*the highest concentration of specific pollutants or parameters in water that are not expected to pose a significant risk to the majority of species in a given environment...*". No acute or chronic toxicity values are assigned for calcium, fluoride, molybdenum, sulfate, or radium in fresh water. Arsenic, cadmium, and chloride are assigned both acute and chronic values:

- Arsenic acute = 0.340 mg/L and chronic = 0.150 mg/L
- Cadmium acute = 0.002 mg/L and chronic = 0.0007 mg/L
- Chloride = 860 mg/L and chronic = 230 mg/L

The EPA Aquatic Life values are not specific to certain animal, plant or other biological species. At high levels, arsenic competes with phosphate in plant processes, forming unstable cells or chemical complexes plants are unable to metabolize. Cadmium can interfere with plant photosynthesis, root formation and metabolism. Symptoms of chloride toxicity include stunted growth of plants at moderate levels, to levels that prevent plant growth or germination when extreme concentrations are present (NIH, 2015).

The concentrations found in groundwater at the Ash Pond are below both acute and chronic levels for arsenic and chloride. Only cadmium exceeds its chronic value, but background cadmium values in facility groundwater also exceed this value. If groundwater was being used for irrigation or stock water, they could pose a low risk to impacts on soil chemistry and/or plant growth. However, impacted groundwater is not utilized for any beneficial use purposes on the plant, and is contained within the plant boundary. Based on these factors, no short-term impacts are expected to the environment, while corrective measures are evaluated for the CCR Landfill.

Little or no impact on wildlife is expected from impacted groundwater, as it is not presently brought to the surface for any uses or treatment. As a result, wildlife exposure pathways are incomplete.

No impacts to facility structures have been observed due to the trace levels of these constituents found in groundwater at the plant. Based on this, no long-term damage to plant operations or structures are expected to occur in the future.

3.4 Clean Up Levels / Attainment Criteria

The following sections provide a description of the conceptual site model at the Dave Johnston Power Plant, define points of compliance for monitoring remedy efficacy, the cleanup levels for remedy implementation, and the current and proposed corrective measures. The *Final Rule* prescribes what clean-up levels will be implemented and what will constitute attainment at all CCR units as follows:

> *Compliance with the groundwater protection standards established under § 257.95(h) has [have] been achieved by demonstrating that concentrations of constituents listed in appendix IV to this part have not exceeded the groundwater protection standard(s) for a period of three consecutive years using the statistical procedures and performance standards in § 257.93(f) and (g).*

The *Final Rule* dictates the clean-up levels for the selected remedy at the Dave Johnston Ash Pond. Table 6 lists the groundwater protection standards developed based on 2018 monitoring data, coupled with guidance provided in the July 2018 modification to the *Final Rule* (EPA 2018).

Table 6. Groundwater Protection Standards

Analyte	Groundwater Protection Standard (mg/L)
Antimony	0.006
Arsenic	0.012
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Cobalt	0.12
Fluoride	4
Lead	0.06
Lithium	0.1
Mercury	0.002
Molybdenum	0.100
Radium	6.8
Selenium	0.05
Thallium	0.002

3.5 Point(s) of Compliance

The *Final Rule* prescribes points of compliance for CCR units where groundwater protection standards have been exceeded, as follows:

> *The owner or operator of the CCR unit demonstrates compliance with the groundwater protection standards established under § 257.95(h) has been achieved at all points within the plume of contamination that lie beyond the groundwater monitoring well system established under § 257.91.*

The *Final Rule* also mandates that groundwater monitoring must be conducted at the waste unit boundary under *§ 257.91*. This means, all groundwater impacted by a release beyond the waste unit boundary must be addressed as part of the selected remedy.

3.6 History of Corrective Measures

PacifiCorp has monitored and assessed environmental impacts, since the 1970s starting with initial permitting of the Ash Pond. In addition, a series of studies have been completed to assess potential impacts from various areas on the facility. Following the 1992 study which indicated groundwater impacts from the Ash Pond were occurring, the pond was upgraded. In 1992, 2.5-feet of compacted clay soil was placed on excavated slopes, and the pond bottom was lined with 3-feet of compacted clay (Tetra Tech 2016).

To augment the initial pond upgrade, a flexible membrane liner was installed in 1995. Groundwater monitoring after the liner system was installed determined the liner was successful in reducing contaminant loading in the upper aquifer following its installation. Ongoing monitoring continued to show decreasing concentrations in the groundwater through 2016 most likely due to natural attenuation, however, the2017 and 2018 groundwater monitoring results suggest the Ash Pond is again impacting groundwater.

4.0 ASSESSMENT OF CORRECTIVE MEASURES

As required by CCR regulations, various potential corrective measures for the Ash Pond were evaluated. They were screened based on several factors including the specific elements defined in § 257.96:

- Performance
- Reliability
- Ease of Implementation
- Potential Safety Impacts
- Cross-Media Impacts
- Exposure Control to Residual Contamination

State permits require the closure by removal of the Ash Pond. Closure is scheduled to begin in the fall of 2019. Closure by removal will include the removal of all waste material, the liner system, and all impacted soil. Closure by removal, therefore, is the baseline or no action corrective measure. All other correctives measures evaluated are in addition to closure by removal and address residual groundwater impacts. Corrective measures to address residual groundwater impacts include; extracting groundwater and using and/or treating the extracted water and treating the impacted water in-situ. Two pump and treat and five in-situ treatment options were evaluated. Table 7 provides a summary of the evaluation. The corrective measures evaluated are listed below and discussed in the following sections.

1. Closure by Removal
2. Pump & Treat
3. Impermeable Barrier with Pumpback
4. Reactive Permeable Barrier
5. In Situ Injection of Reactive Compound
6. Phyto-Remediation
7. Electro-Kinetics

4.1 Closure by Removal

Normally the "no action" alternative is included as a baseline to compare the benefits of more active remedial measures. However, for the Ash Pond, the "no action" alternative includes closure by removal as per WDEQ regulations and in compliance with the "*Final Rule*". All waste will be removed from the Ash Pond and transported and placed into the onsite Expansion Landfill, per the approved Construction Permit. In addition, all impacted soil that can be feasible excavated will also be removed. Once removal and compaction are complete, the waste will be managed in accordance with the landfill permit.

Performance. This alternative will provide the most permanent remedy to existing conditions by removing the waste from the current cell and placing it in a permitted landfill. The removal of the waste and impacted soil would prevent contact with groundwater moving forward with only periodic inspection and maintenance requirements. The removal would not actively capture or treat groundwater but is still expected to meet groundwater protection standards in a fairly short time period.

Reliability. Landfilling and capping of the ash will meet all reliability requirements and is a proven method for final disposal at Dave Johnston. Multiple historical landfills have been operated and closed at the facility with no long-term groundwater impacts. By isolating the waste in a controlled setting, contact with groundwater in the future will be eliminated. This alternative would not actively address impacted groundwater.

Implementation. Siting of a new repository would not be necessary, as available space has been identified in the permitted Expansion Landfill on the plant facility. This landfill is near the Ash Pond and would not require moving materials offsite and would reduce public safety issues involved with offsite transportation of wastes.

Potential Environmental / Safety Impacts / Exposure Control. Increased chances of worker exposure would require mitigation during excavation of existing waste, and transport and placement in the new repository. Heightened potential for releases to the environment would also require mitigation, to ensure FGD-waste is not released as fugitive dust or as a result of spills or accidental dumping. Exposures to workers and releases to the environment can be mitigated through safe work practices and stormwater management.

Time to Implement / Complete. The excavation and placement of the Ash waste can begin as soon as a replacement pond is constructed. Design is complete and permitting is in process for the new ash Pond. Construction is scheduled for summer of 2019. Closure by removal is estimated to be completed within one year. It is expected that dissolution of residual contamination will take place fairly quickly in this highly conductive aquifer. The estimate for groundwater compliance is 5 years.

Permits & Public Health Requirements. Since all construction and hauling will be completed on the plant property where access is controlled and all workers will be required to comply with a Construction Health and Safety Plan, no public health issues are anticipated. No additional permitting is required.

Summary. Closure and removal of the Ash Pond by excavation and placement of the CCR material in the existing landfill is implementable and already designed and permitted. This alternative will provide the most permanent solution to waste interacting with groundwater over the long-term. It does not actively address near term attainment criteria prescribed in the *Final Rule*.

4.2 Pump and Treat

Pump and Treat involves the physical extraction of impacted groundwater to either remove contaminant mass from the subsurface and/or to hydraulically control plume migration. The extracted water is then used in a plant process or treated through a variety of methods.

Performance. Pump and treat is a proven technology in use for a variety of similar applications and with performance monitoring and optimization, can be successfully applied at this site. Treatment of captured groundwater would be required. This alternative actively addresses the impacted groundwater and would reduce the time required to reach the attainment of the groundwater criteria at the waste unit boundary, by removing impacted groundwater in recovery wells.

Reliability. Pump and treat technologies are widely used in the industry to capture / collect contaminated groundwater and contain or treat it to meet discharge standards. Recovery wells, pumps and piping would make up the recovery network, which in general, are low maintenance items. Periodic maintenance of each will be required to remove scaling that will eventually build up due to contact with shale water. These activities can be built into a regular schedule at low costs and without disruption to plant operations.

Implementation. Installation of the pumping system is not complex. Based on an understanding of site hydrogeology and informed by pilot testing, a series of wells could be installed to capture groundwater as it passes the Ash Pond boundary. System optimization requires frequent performance monitoring early-on, to ensure effective groundwater recovery. Pump and treat is fully implementable at this site.

Potential Environmental / Safety Impacts / Exposure Control. Captured groundwater would be contained in piping and sent for treatment or used in a plant process. Worker exposures are possible during active O&M activities. The remainder of the time captured water should be contained before treatment.

Time to Implement / Complete. The pump and treat alternative could likely be designed and installed in one year. Optimization would be ongoing through performance monitoring, with frequent monitoring during the first year and reduced monitoring once the system has been optimized.

Pump and treat would reduce the time to compliance by approximately 1 year; however, large volumes of groundwater would need to be pumped in order to have a significant effect on the time to meet standards.

Permits & Public Health Requirements. This remedial technology would require permitting and design through the State agencies, which may require significant time in the review and design process. Both DEQ and water rights issues would need to be resolved and permitted prior to implementation, which could require up to one year. Public health impacts would be minor since site access is controlled.

Summary. The pump and treat technology is fully implementable and reliable and would offer the capability to reach attainment at the waste unit boundary. A pilot study would be required to determine the quantity of water that will be recovered, and if current plant infrastructure can accommodate captured water for treatment.

4.3 Impermeable Barrier / Pumpback System

An impermeable barrier is a cement/bentonite mix placed in the subsurface as a designed wall. The wall is designed to stop groundwater flow and contaminant migration. By itself, an impermeable wall is unlikely to achieve attainment in areas of continuous, high groundwater flow. An impermeable barrier usually results in bypass of groundwater along new flow paths, which bypass the barrier. A groundwater pumpback system would be required to supplement an impermeable barrier to limit migration of contaminants, through groundwater capture and/or hydraulic control. This measure can direct groundwater to an area where a pumpback system can be optimized.

Performance. An impermeable barrier and pumpback system would offer a long-term containment measure for impacted groundwater. The barrier would direct / contain groundwater in a localized area, allowing for the pumpback system to capture water.

Reliability. While the impermeable barrier technology has been utilized successfully for a number of environmental applications, site-specific considerations will determine whether or not the barrier can effectively serve as an underground dam, directing water to the pumpback system. Significant geotechnical evaluation of drainage downgradient of the landfill would be needed, to determine if the barrier can be constructed and perform its function. The reliability of the impermeable barrier is unknown. If properly designed, the pumpback technology is reliable and effective in capturing impacted groundwater and providing hydraulic control in the aquifer.

Implementation. Implementing this alternative is very invasive. Large excavations are required to accommodate placement of the barrier. Groundwater flow would require evaluation following the barrier installation, to optimize the placement and construction of pumpback wells. Because of the subsurface composition, excavations of this size would require significant sloping or shoring.

Potential Environmental / Safety Impacts / Exposure Control. Of the available alternatives, impermeable barriers offer some of the highest risks of exposure to workers. Excavations will expose the aquifer and dewatering is required during installation. The predominately sand subsurface would require addition shoring or sloping techniques to ensure worker safety. Workers may be exposed to contaminated groundwater throughout this process. The risk to release of impacted groundwater is very high as well, because the aquifer material is exposed, and groundwater inflow is being actively managed. While dewatering can be done safely and controlled, exposure control will take significant effort to mitigate.

Time to Implement / Complete. The design element of this alternative is likely to be time intensive, for engineering design and installation. Once installed, aquifer evaluation will be required to determine the proper placement and construction of pumpback wells. Performance monitoring will be required to determine effectiveness over the short-term. Installation will likely require one construction season to prepare the site and install the barrier.

Given the extensive permitting and construction timelines, this alternative would not reduce the time period for compliance.

Permits & Public Health Requirements. State permits would be required to design and install an impermeable boundary and a pump and treat system. Both DEQ and water rights issues would need to be resolved and permitted prior to implementation, which could require up to one year. With respect to public safety, site access control would need to be maintained to limit public exposure to the pumped water.

Summary. An impermeable barrier and pumpback system would allow for active capture and treatment of impacted water. Water management may require the construction of additional storage ponds, unless current infrastructure is sufficient to store captured water. Installation of the barrier will be very invasive and will require special planning. Given the hydrogeologic setting of the Ash Pond, the likelihood of successfully installing the barrier is questionable.

4.4 Reactive Permeable Barrier

A reactive permeable barrier (RPB) is a placed to intercept contaminants along the groundwater flow path within a contaminant plume. The RPB is designed to react with and/or reduce the toxicity or mobility of contaminant as it passes through the barrier. When properly designed, the contaminant is immobilized in the wall or degraded by compounds used in construction of the wall.

Performance. A reactive permeable barrier can be very effective in treating groundwater where the flow path is well understood or contained, and the quantities of groundwater undergoing treatment are well understood. Treatability testing would be required to determine the optimal composition of an RPB to address impacted groundwater. It is unlikely an RPB could be installed such that attainment could be reached at the waste unit boundary.

Reliability. RPBs would offer low to moderate reliability. Because they are designed to react with groundwater, several factors affect their ability to function over the long-term, including breakthrough in areas of higher than expected groundwater flow, burnout due to localized flow, and the need to remove and/or replenish the reactive compound due to interactions with contaminants. As a result, RPBs can include long-term O&M and periods of down-time for the system, while maintenance or replacement takes place.

Implementation. Implementing this alternative is very invasive. Large excavations are required to accommodate placement of the barrier, and similar invasive activities are needed to maintain them. Treatability testing would be required to determine if an RPB will effectively support removal of metals from impacted groundwater at the facility.

Potential Environmental / Safety Impacts / Exposure Control. Of the available alternatives, RPBs offer some of the highest risks to exposure from workers. Excavations will expose the aquifer and dewatering is required during installation. Workers may be exposed to contaminated groundwater throughout this process. The risk to release of impacted groundwater is very high as well, because the aquifer material is exposed, and groundwater inflow is being actively managed. While dewatering can be done safely and controlled, exposure control will take the significant effort to mitigate.

Time to Implement / Complete. RPBs will require relatively intensive testing in order to design a barrier that will be effective in treating the metals found in groundwater. The design element of this alternative is likely to be time intensive, both from a RPB composition perspective, and for engineering design and installation. Once installed, the RPB will begin treating impacted groundwater. Performance monitoring will be required to determine its effectiveness. Installation will likely require one construction season to prepare the site and install the RPB. The overall time to compliance will not be decreased as compared to Closure by Removal.

Permits & Public Health Requirements. Additional permits would be required through State agencies to design and construct an RPB. Since the material is reactive, public safety would need to be considered during implementation. Site controls will be required during implementation and operation of the system.

Summary. An RPB offers some very favorable aspects, specifically passive treatment of impacted groundwater throughout the year. Implementing this alternative will take 2 to 3 years, and long-term O&M will be required, until closure by removal is complete, and groundwater impacts are reduced to levels below groundwater protection standards. Treatability testing will be required in order to determine the feasibility of this alternative. Based on this, the likelihood of success for an RPB is unknown.

4.5 In Situ Injection of Reactive Compound

In-situ injection involves introducing an agent into the subsurface that physically reacts with the contaminants to degrade, stabilize or immobilize the contaminant in the aquifer. Knowledge of all contaminants and the geochemistry of the aquifer matrix and the water is required to successfully implement this technology.

Performance. Injection of chemicals to treat impacted groundwater is unlikely to be successful as a standalone alternative. While in situ treatment could result in decreased mobility of metals in the aquifer over the short-term, the homogeneity of impacted aquifer contaminants and depth of the profile it occupies, are unlikely to result in the successful placement of chemicals to treat all compounds in the aquifer.

Reliability. The reliability of chemical treatment of pond wastes will require a pilot study, to determine if chemicals can be effectively applied within the waste or aquifer profile, and if chemical applications immobilize FGD-related constituents sufficiently to support long-term attainment of objectives. Presently, the reliability of this alternative is unknown.

Implementation. A pilot study would be required to determine if chemical(s) could be applied in the waste across the entire depth profile to effectively immobilize contaminants of concern. The study would also seek to identify which chemical applications have the greatest chance of success to support the cleanup objectives. Because these factors are unknown at this time, the ability to implement this alternative is also unknown.

Potential Environmental / Safety Impacts / Exposure Control. In situ application of chemicals to the aquifer would be relatively non-invasive. Likely chemicals would be injected through temporary wells, placed in or downgradient of the pond, based on the pilot study results. Manageable amounts of waste (drill cuttings) would be generated during this process, but safe work practices can mitigate risks to workers. Cuttings can be placed in the pond along with other plant waste to mitigate the potential for releases to the environment during active treatment. Exposure to the treatment chemicals while handling and injecting would pose a risk to workers but can be reduced by a Health and Safety Plan and engineering controls. Reactions within the waste would be designed to immobilize specific chemicals. The pilot study will be critical to determining if this mitigates risks of mobilizing of contaminants to the environment.

Time to Implement / Complete. The pilot study could require up to a year to complete. Vertical profiles of the impacted areas would have to be acquired as core samples, followed by batch testing to determine the efficacy of potential chemical amendments. If the pilot test concludes this alternative is viable, chemical injections could begin after the injection well network is developed and installed. Performance monitoring would be frequent during the first year to ensure the effectiveness of the treatment.

If the injectate can degrade all contaminants and be placed under the pond footprint, time to compliance can be reduced. Time to compliance could be on the order to 2 to 10 years.

Permits & Public Health Requirements. Remedial activity would require permitting and design documents to be approved by the State Agencies. Public health impacts are not expected since site access is controlled, and the majority of the work will be completed in the subsurface.

Summary. If successful, in situ injection of reactive chemicals would immobilize FGD-related constituents in the groundwater, reducing or eliminating their mobility in groundwater. Treatability testing is required in order to determine if this alternative can be implemented in the heterogenous waste profile in the impacted area of the aquifer.

4.6 Phyto-Remediation

Phyto-remediation is the use of plants or vegetation to uptake contaminants in soil or water and immobilize the contaminant in the cell structures. Specific to groundwater remediation, the selected plant(s) must be in contact with groundwater and thrive while processing the contaminants. Groundwater elevations at the site are much deeper than the normal root zones of plants that can survive the arid climate of Wyoming and year-round growth of plants is not achievable.

4.7 Electro-Kinetics

Electro-kinetic methods induce a low intensity direct current through the soil or groundwater using a cathode and anode array. The current causes positively charged ions to move toward the cathode and negatively charged ions to move toward the anode, where they can be captured or immobilized.

Performance. Electro-kinetic methods can be effective in treating source areas, localized or contained contamination, and in relatively homogeneous aquifer settings. It is not clear this alternative can treat groundwater over the spatial area impacted by discharge from the Ash Pond or the range of both contaminants and natural compounds present at the site. A pilot study would be required to determine the viability of this alternative under site-specific conditions.

Reliability. This alternative has been demonstrated as an effective treatment under the right conditions. During active treatment, poles in the system foul over time, due to electro-plating of desired constituents during treatment. This results in periods of decreasing efficacy and down time to eliminate the effects of fouling. The reliability of the system would be considered moderate.

Implementation. Electro-Kinetic remediation requires a specific contaminant that is attracted to a cathode or anode in an array or a contaminant that can be destroyed by heat. In addition, these methods consume electricity at a very high rate and can only be operated for short periods of time due to the cost. They can be effective if the contaminant is in high concentrations or very limited in extent. As is the case at CCR units, the contaminants are typically dispersed over a large area and in low concentrations once in groundwater. As a result, the ability to implement this alternative is questionable.

Potential Environmental / Safety Impacts / Exposure Control. Potential exposures to workers could occur during installation of the system, and during periods of maintenance. Because the system treats groundwater in situ, additional exposure to workers or releases to the environment are not anticipated during active operations. The use of electricity does pose a risk to workers.

Time to Implement / Complete. A pilot study would be required to determine if electro-kinetics will serve as a viable alternative to treating impacted groundwater. The pilot study and system design will require a year. Installation could be completed in three to six months, with system optimization to follow. The time to complete with electro-kinetic option depends directly on the ability to contact all groundwater with the technology for a period of time required to remove or immobilize all contaminants in the plume. Given site conditions, if the technology could be implemented, it may reduce time to compliance by 3-5 years.

Permits & Public Health Requirements. Remediation would require a very specific design and a complicated permitting effort, since the technology is not used extensively. A detailed pilot study would be required to collect the data needed to complete the permitting process. As a result, significant time would be required to obtain the necessary permits. Public health issues are not expected since site access is controlled.

Summary. A detailed pilot study would be required to determine site-specific conditions would lend themselves to effective treatment using electro-kinetics. Based on these findings, an array would be designed and installed to treat impacted groundwater. At present, the viability of electro-kinetics to achieve attainment at the waste unit boundary are unknown.

Table 7. Alternatives Screening

Regulatory Reference	257.96 (c) (1)						257.96 (c) (2)		257.96 (c) (3)
Corrective Measure – Alternative:	**Performance**	**Reliability**	**Implementation**	**Potential impacts of Remedy**	**Safety Impacts**	**Control of exposure**	**Time required to begin**	**Time required to complete**	**State & Local Permits, Public Health Requirements**
Closure by Removal	+	+	+	+	=	=	+	+	+
Pump & Treat	+	+	+	+	+	+	+	+	=
Impermeable Barrier with Pumpback	+	-	-	-	-	-	-	=	-
Reactive Permeable Barrier	-	-	-	-	-	-	-	-	-
In Situ Injection of Reactive Compound	-	-	-	=	-	+	-	-	
Phyto-Remediation	NV								
Electro-Kinetics	-	-	-	=	-	-	-	-	-

+ Positive
- Negative
= Neutral
NV – Not Viable

4.8 Corrective Measures Alternatives

Sections 4.1 through 4.7 presents the evaluation of the eight corrective measures. The evaluations indicate that closure by removal – removing all waste and as much impacted soil as possible – will remove all ongoing source material and will achieve compliance with all groundwater protection standards in 5 years. Closure by removal is required at the site under state regulations. Active treatment of the impacted groundwater would reduce the time by approximately 1 year for the impacted groundwater to meet groundwater protection standards under the rule. From the evaluations, a pump and treatment system is the preferred option to actively treat the impacted groundwater. Based on the evaluation, two corrective measures alternatives appear to be the most applicable to address groundwater impacts associated with the Ash Pond:

1. Alternative 1 – Closure by Removal

2. Alternative 2 – Closure by Removal with a Pump and Treat System

5.0 SELECTION OF THE REMEDY

The remedy at the CCR Landfill will be selected following public meetings / public comment. The remedy selected will be determined by utilizing the requirements in § 257.96 in the *Final Rule.*

6.0 REFERENCES

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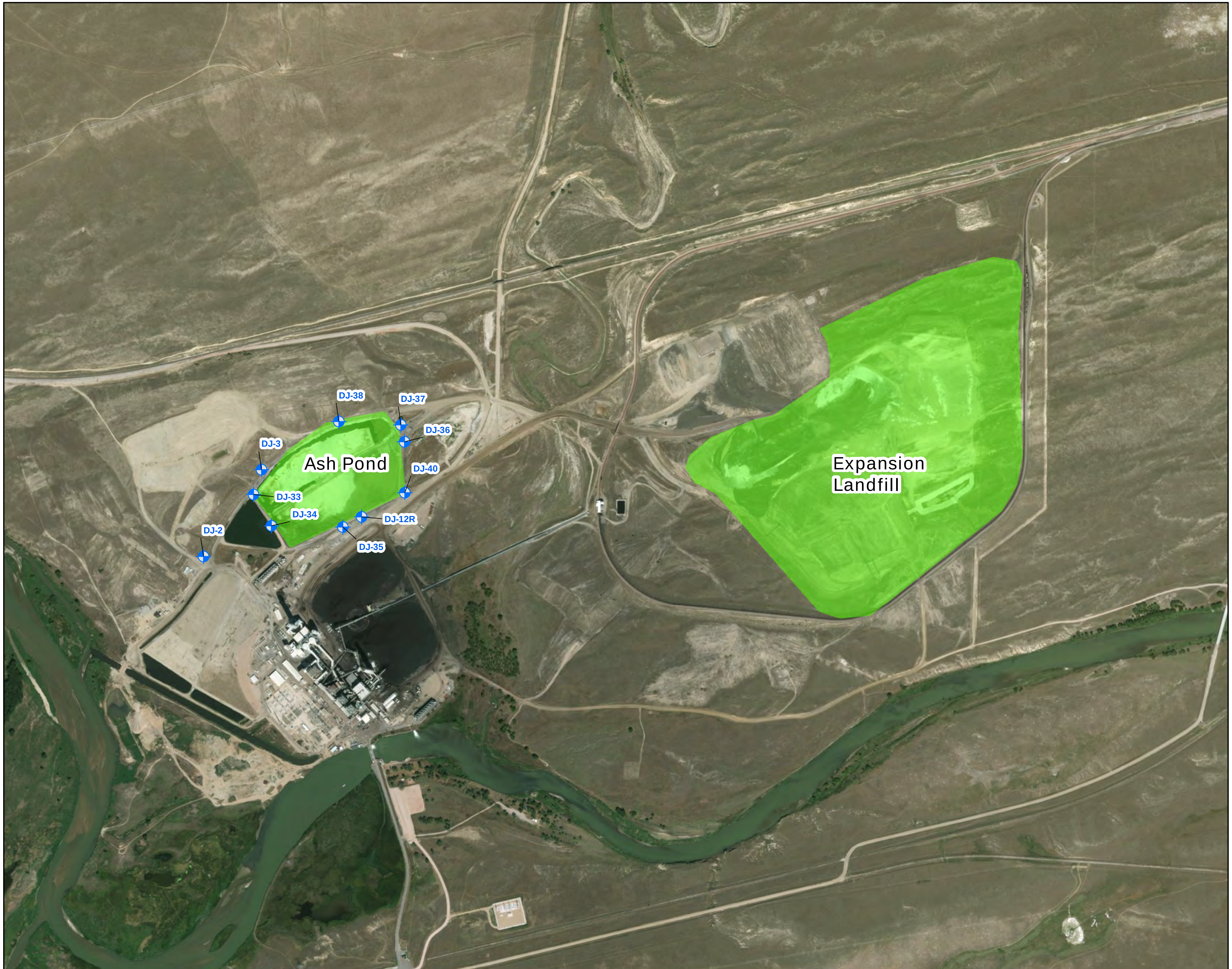
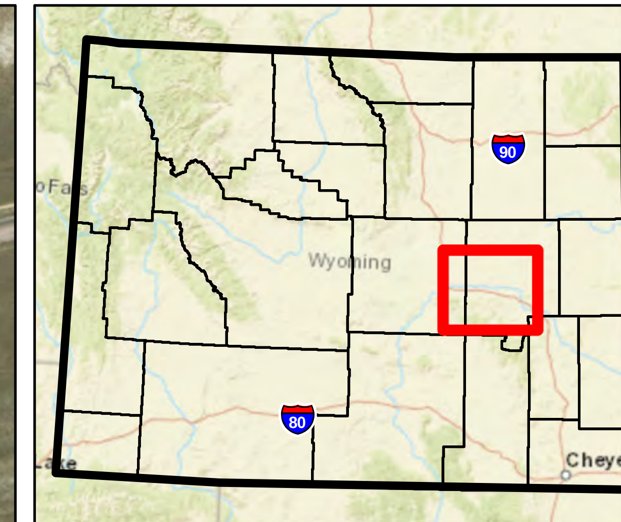
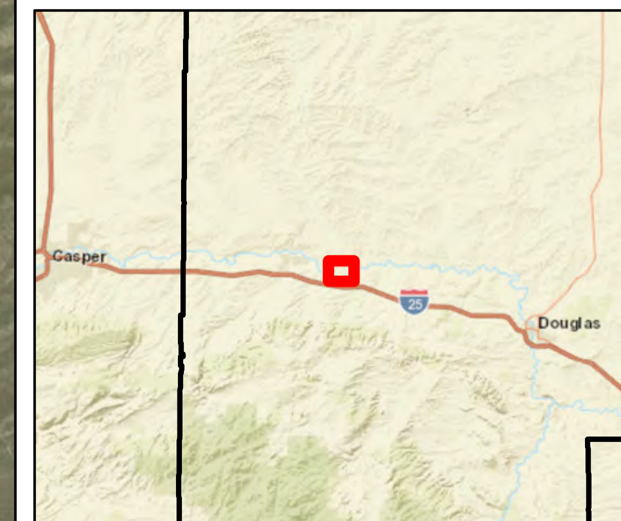
FIGURES







*Note background image is 2016
1 ft. resolution ESRI Aerial

Legend

CCR Wells

CCR Units

Feet

0 500 1,000 2,000

N S E W

PACIFICORP

WET Water & Environmental Technologies

DAVE JOHNSTON POWER PLANT

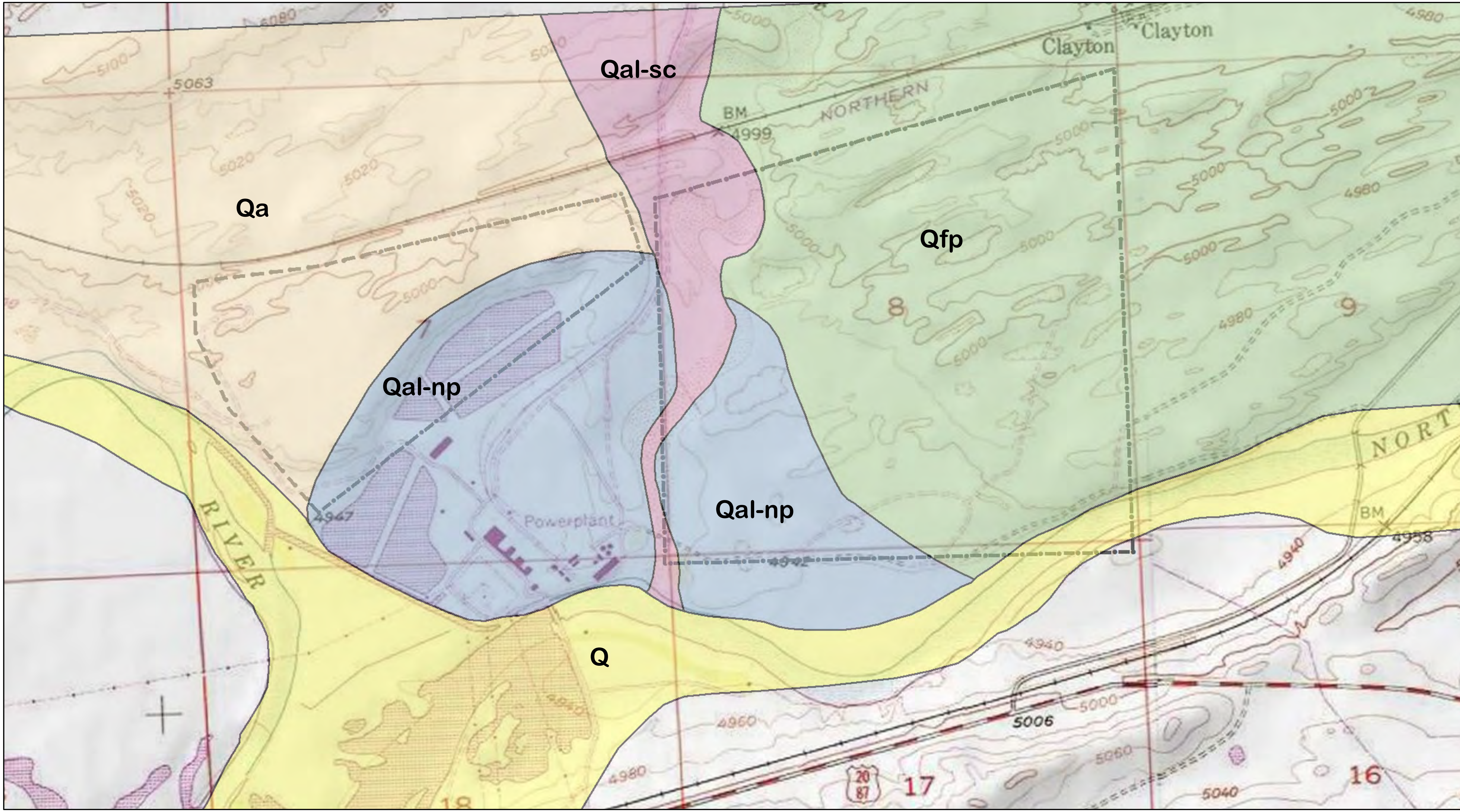
Ash Pond
CCR Sampling Locations

Job#: PERCM50

Date: 1/22/2018

FIGURE 1

Path: M:\PERC_CCR\Dave_Johnston\AshPond_CCR_Sampling.mxd, Author: brutherford



Legend

- Qal-sc, Sand Creek
- Qal-np, North Platte
- Qa, Aeolian
- Qfp, Flood Plain
- Q, Recent
- Permit_Bound

N W E S

Feet
0 500 1,000 2,000 3,000 4,000 5,000

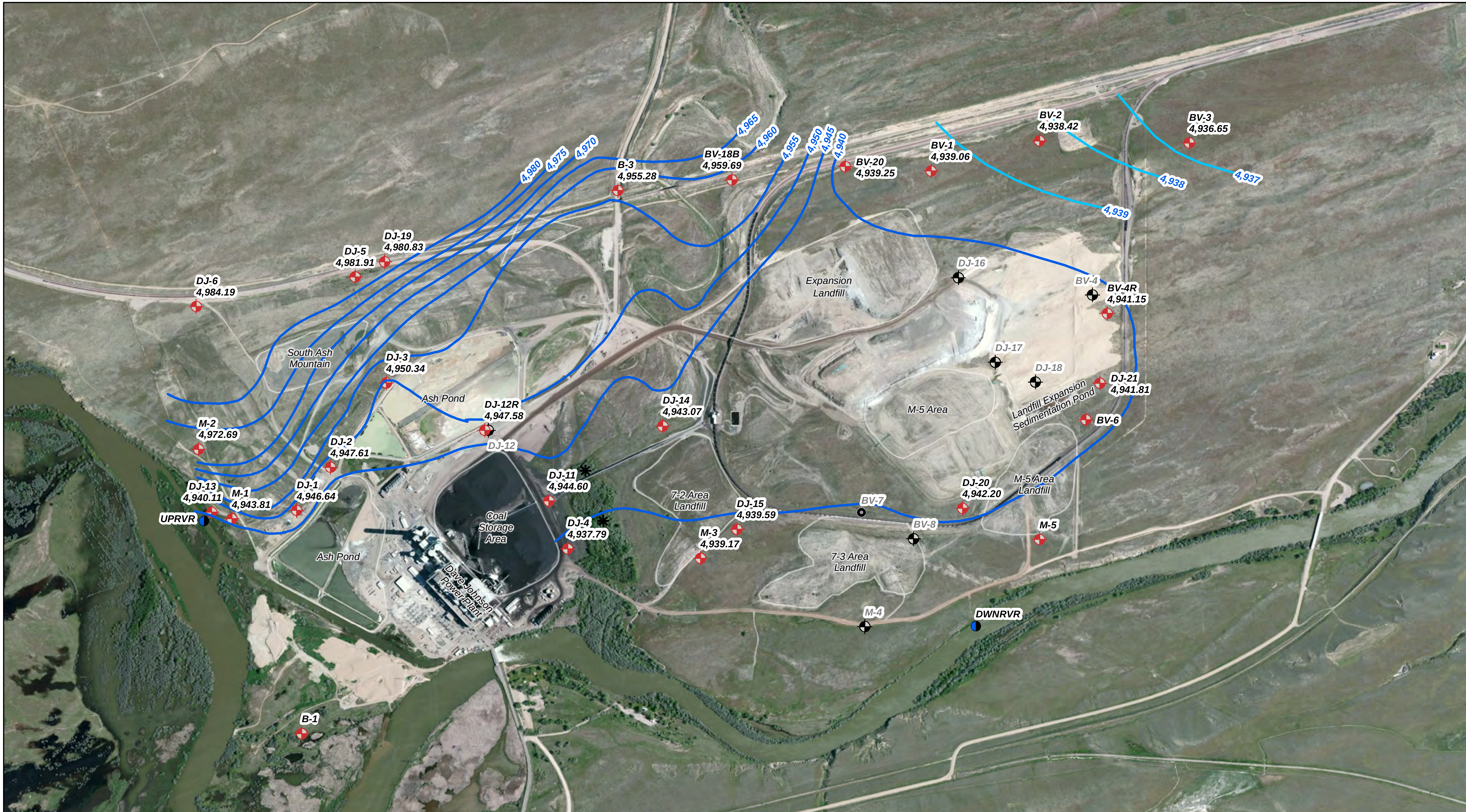
PACIFICORP
WET Water & Environmental Technologies

DAVE JOHNSTON POWER PLANT

Geologic Map - First Water Bearing Zone

Job#: PERCM55	**FIGURE 2**
Date: 10/25/2017	

Path: M:\PERC_CCR\Dave_Johnston\Figure2_Geology.mxd, Author: jleprowse



Legend

- Monitoring Well
- Surface Water Sampling Point
- Abandoned Monitoring Well
- Abandoned Exploration Boring
- Groundwater Elevation Contour (1 ft.)
- Groundwater Elevation Contour (5 ft.)
- Well has been extended, GWE not used for contours

N
W E
S

Feet

0 500 1,000 2,000

PACIFICORP

WET Water & Environmental Technologies

DAVE JOHNSTON POWER PLANT

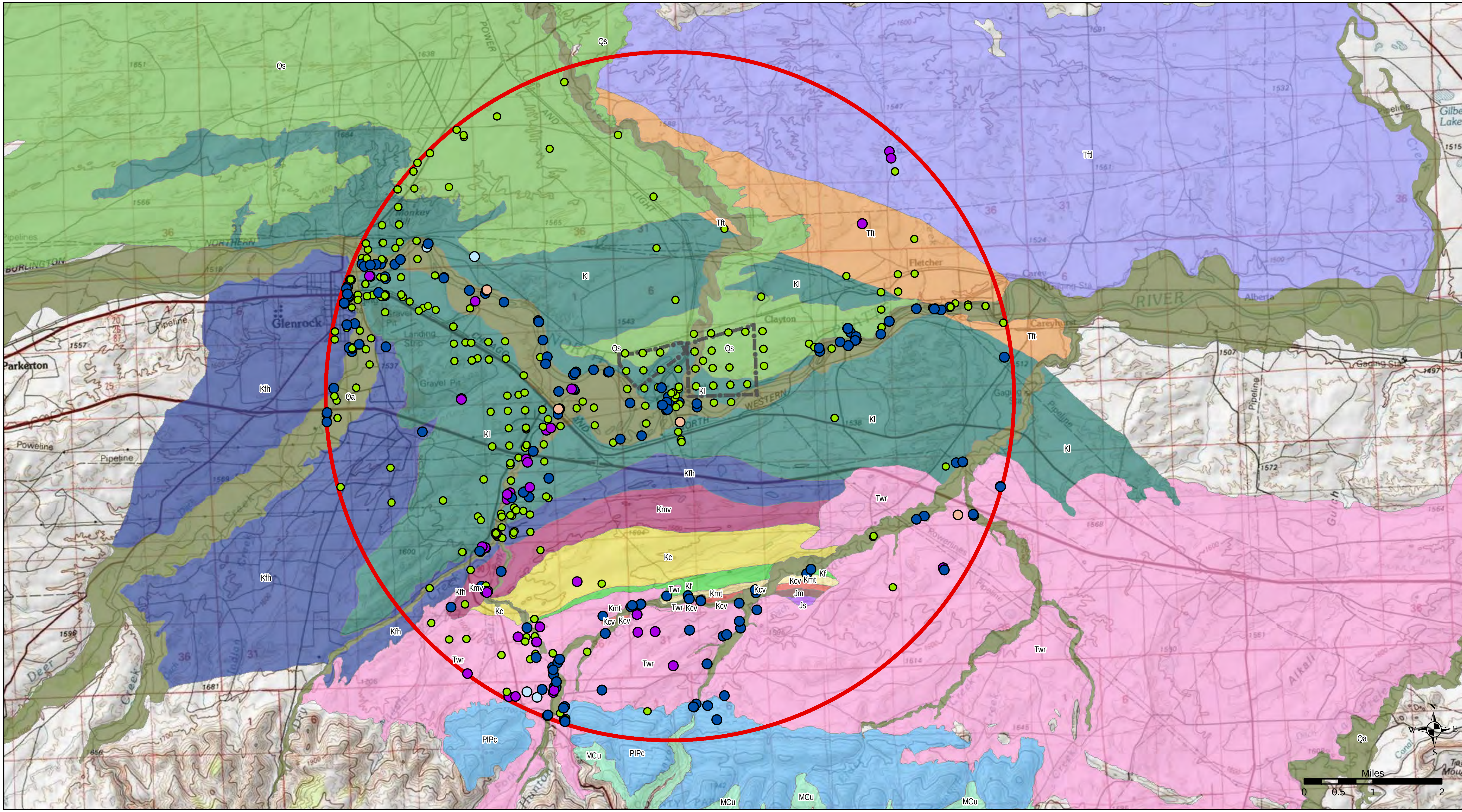
Groundwater Contour Map
Fall 2018

Job#: PERCM01

Date: 3/8/2019

FIGURE 3

Path: M:\Dave Johnston\2018_Report\DDPs.mxd, Author: ceggensperger



Legend

Facility Type		Geology Unit				
Reservoir	Well	Jm	Kcv	Kmt	Qa	Twr
Spring	Uknown	Js	Kf	Kmv	Qs	
Stream	Site Buffer (5 mi.)	Kc	Kfh	MCu	Tft	
	Permit_Bound		Kl	PIPc	Tftl	

PACIFICORP

WET Water & Environmental Technologies

DAVE JOHNSTON POWER PLANT

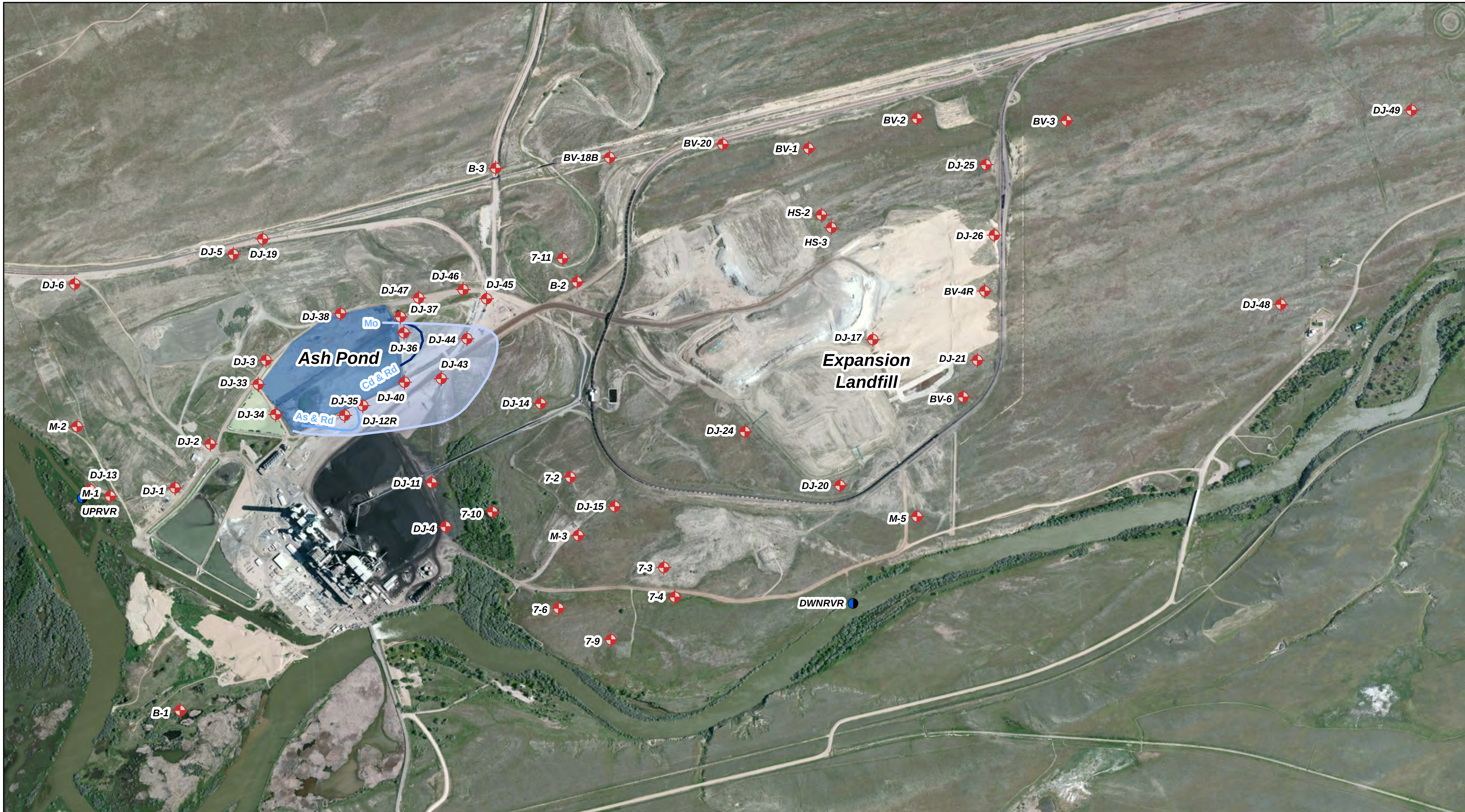
Vicinity Point of Diversion Map

Job#: PERCM50

Date: 4/10/2019

FIGURE 4

Path: M:\PERC_CCR\Dave_Johnston\Figure2_Geology.mxd, Author: jleprowse



Legend

- Monitoring Well
- Surface Water Sampling Point
- As - Arsenic & Rd - Rubindium
- Cd - Cadmium & Rd - Rubindium
- Mo - Molybdenum
- Groundwater Plume
- Ash Pond

N
W E
S

0 400 800 1,600 2,400 3,200 4,000 Feet

PACIFICORP

WET Water & Environmental Technologies

DAVE JOHNSTON POWER PLANT

APPENDIX IV - GROUNDWATER EXCEEDANCES

Job#: PERCM101

Date: 3/8/2019

FIGURE 5

Path: M:\Dave Johnston\2019\AppIV_Figure_2.mxd, Author: jslocum