2019 Annual Groundwater Monitoring and Corrective Action Report
AVS CCR Landfill

Antelope Valley Station
Beulah, North Dakota

Basin Electric Power Cooperative

Basin Electric Power
Cooperative
Bismarck, North Dakota

Quality information

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	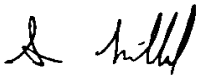		

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Attachments

List of Acronyms

AECOM	AECOM Technical Services, Inc.
AVS	Antelope Valley Station
Basin	Basin Electric Power Cooperative
bgs	below ground surface
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
cm/sec	centimeters per second
EPA	United States Environmental Protection Agency
FGD	Flue Gas Desulfurization
ft., amsl	feet above mean sea level
ft., bgs	feet below ground surface
GWPSs	groundwater protection standards
LPL	lower prediction limit
mg/L	milligrams per liter
mw	megawatts
RCRA	Resource Conservation and Recovery Act
SSI	statistically significant increase
SSL	statistically significant level
TDS	total dissolved solids
UPL	upper prediction limit

1. Introduction

On behalf of Basin Electric Power Cooperative, (Basin), AECOM has prepared the 2019 annual report documenting groundwater monitoring and corrective action for the Coal Combustion Residuals (CCR) Landfill at Basin's Antelope Valley Station (AVS).

Chapter 1 provides background information on the power generating facility, the CCR unit(s) present at the facility, and the physical setting of the CCR unit(s), specifically with regard to groundwater conditions. Chapter 2 summarizes CCR groundwater monitoring activities conducted prior to 2019. Chapter 3 summarizes the groundwater monitoring and corrective action activities completed in 2019, and references attachments to this report that contain detailed documentation of those activities. Chapter 4 provides an evaluation of the condition of the groundwater monitoring system. Chapter 5 summarizes the groundwater sampling and analysis conducted during the reporting period. Chapter 6 reviews the methods and results of statistical analysis of the groundwater monitoring data. Chapter 7 presents a summary and conclusions from the CCR groundwater monitoring in 2019 and statistical analysis of the results. Chapter 8 lists references cited in this report.

Regulatory Background

The CCR rule became effective on October 19, 2015 and established standards for the disposal of CCR in landfills and surface impoundments (CCR units). In particular, the rule set forth groundwater monitoring and corrective action requirements for CCR units. The rule includes the requirement for an "annual groundwater monitoring and corrective action report" (annual report), due by January 31 of the year following the monitoring period. The annual report is intended to document the status of the groundwater monitoring and corrective action program for each CCR unit, summarize key actions completed in the previous year, and project key activities for the upcoming year. This report is the third annual report, and includes activities performed in calendar year 2019.

Facility Location and Operational History

AVS is a coal-based generating station located north of Beulah, North Dakota (**Figure 1**). The plant consists of two power generating units with a total power output capacity of 900 megawatts (MW):

- Unit 1, with a rating of 450 MW, which began operating in 1984;
- Unit 2, with a rating of 450 net MW, which began operating in 1986; and

CCR produced at AVS includes fly ash, bottom ash, and flue gas desulfurization (FGD) waste.

CCR Unit Description

CCR is disposed at AVS in the following CCR unit:

- Section 7 Ash Landfill 0160 (CCR Landfill)

The CCR Landfill is located northeast of the generating units and office complex, in an area of mine spoils identified as the Couteau Properties Freedom Mine (**Figure 1**). Basin reported that in 2019 the Landfill received 832,665 tons of solid waste, including fly ash, FGD waste, and a minor contribution of solid debris.

Physical Setting

The geology underlying the site includes mine spoils underlain by the Sentinel Butte Formation. This formation is comprised of continental deposits in excess of 1,000 feet thick, consisting of dense clay, weakly cemented sandstone, mudstone, and lignite.

Precipitation supplies surface water to perennial and ephemeral streams that flow generally east toward the Beulah Trench then draining north towards Lake Sakakawea. Groundwater is recharged primarily through regional infiltration of melt water in the spring.

The base of the AVS CCR Landfill is underlain by 115 to 200 feet (approximately) of clay-rich mine spoil that overlies the Lower Sentinel Butte Formation. The Sentinel Butte is comprised primarily of dense clay with trace very fine sand and beds of lignite typically ranging from 6- to 9-feet thick at the site. The 2016 AECOM drilling investigation did not penetrate to depths great enough to expose the lower portions of the Sentinel Butte.

The uppermost aquifer is found within the 6- to 9-foot unmined lignite bed located at depths ranging roughly from 180 to 260 feet below ground surface (ft., bgs). The potentiometric surface of the uppermost groundwater present within the lignite is approximately 1893 feet above mean sea level (ft., amsl) in the western portion of the Landfill facility sloping generally east to 1880 ft., amsl on the eastern side of the Landfill. The hydraulic conductivity measurements for the uppermost aquifer range from 10^{-5} to 10^{-9} centimeters per second (cm/s).

2. CCR Groundwater Monitoring Activity Prior to 2019

The regulatory process for CCR groundwater monitoring and corrective action is established by 40 Code of Federal Regulations (CFR) Sections 257.90 through 257.98. The process includes a phased approach to groundwater monitoring, leading (if applicable) to the establishment of groundwater protection standards (GWPSs) for each CCR unit. Exceedances of the GWPSs that are determined to be statistically significant can trigger requirements for additional groundwater characterization and corrective action assessment followed by corrective action implementation. The following paragraphs provide a brief summary of CCR groundwater monitoring activities performed prior to 2019. CCR groundwater monitoring activities performed in 2019 are discussed in Chapter 3.

Groundwater monitoring at AVS is performed using a network of monitoring wells that includes both wells to monitor background water quality that is not potentially influenced by the presence of the CCR unit, and wells placed at the downgradient boundary of the unit (**Figure 2**). The hydrostratigraphic positions of the CCR monitoring wells selected for sampling background and downgradient groundwater quality for the AVS CCR Landfill are summarized below:

CCR unit	Background wells	Downgradient wells
Landfill	MW-18(S), MW-19(S)	MW-15(S), MW-16(S), MW-17(S), MW-20(S)

Monitoring well MW-14(S) is being excluded from the groundwater monitoring network due to insufficient water production to obtain a representative sample. However, it remains in place for collection of groundwater level measurements for potential inclusion in the potentiometric map evaluation as appropriate.

Detection Monitoring was initiated in August 2016, which involved sampling groundwater for Part 257 Appendix III and IV constituents over eight Baseline Detection Monitoring events.

Baseline Detection Monitoring events were performed in general accordance with procedures established in the site-specific Sampling and Analysis Plan (AECOM 2018a), which is included in the facility's Operating Record. The Sampling and Analysis Plan describes the procedures for equipment calibration, monitoring well water level measurement, monitoring well purging and sampling, sample custody, sample shipping, laboratory analysis and documentation requirements for each groundwater sample submitted. The results of the baseline monitoring and 2018 Detection monitoring at the AVS CCR Landfill were presented and discussed in the First and Second Annual Groundwater Monitoring and Corrective Action Reports, respectively (AECOM 2018b and AECOM 2019).

If a statistically significant increase (SSI) of any Appendix III constituent relative to background conditions is detected in the downgradient monitoring wells, and cannot be demonstrated to be associated with a source other than the CCR unit, then the CCR rule requires that groundwater monitoring transition from Detection Monitoring phase to the Assessment Monitoring phase.

The results of the 2018 Detection Monitoring for the CCR unit at AVS identified no SSIs relative to background for Appendix III constituents. As a result, the AVS CCR Landfill groundwater monitoring system continued with Detection Monitoring in 2019.

3. CCR Groundwater Monitoring and Corrective Action Activities in 2019

This chapter summarizes the activities conducted at AVS in 2019 to comply with the groundwater requirements of the CCR rule:

- Groundwater Detection Monitoring activities
  - monitoring system evaluation
  - groundwater sampling
  - laboratory analysis
- Statistical analysis of the monitoring results

Further details concerning each of these activities are provided below.

Detection Monitoring Activities

Monitoring System Evaluation

As described in the CCR Groundwater Monitoring System Report (AECOM 2017), monitoring wells were installed around the CCR unit at AVS with appropriate total depth and placement of the well screen to: (1) facilitate collection of representative groundwater samples from the uppermost aquifer, and (2) accurately measure water table elevations to support evaluation of groundwater gradient and flow direction. All monitoring wells comprising the AVS CCR Landfill monitoring system were found to be in good condition during the Detection Monitoring events conducted in 2019.

Analysis of potentiometric surface maps constructed using the depth-to-groundwater measurements obtained during groundwater Assessment Monitoring indicates the direction of groundwater flow is generally to the east, consistent with data collected during previous CCR program monitoring events, and supports the wells selected to represent background groundwater quality and the quality of groundwater downgradient of the CCR units.

Groundwater Sampling and Analysis

Basin continued implementation of the Detection Monitoring program for the CCR Landfill unit in 2019 based on the results of Baseline and Detection Monitoring as discussed in Chapter 2. The 2019 Detection Monitoring events for the CCR Landfill were conducted in May and October 2019 and included analysis of collected groundwater samples for the constituents listed in 40 CFR Part 257 Appendix III.

Detection Monitoring sampling and analysis in 2019 was performed in general accordance with procedures established in the Sampling and Analysis Plan (AECOM 2018a). The results are presented in **Attachment A**, which also includes a representative potentiometric surface map for the uppermost aquifer, inferred groundwater flow direction and estimated velocities, and tabulated summary of field measurements and laboratory analytical data.

Statistical Procedures and Analysis

Statistical analysis of the results of Detection Monitoring in 2018 indicated that no Appendix III constituents had SSIs over background (AECOM, 2019). These results prompted Basin to continue Detection Monitoring in 2019.

The Appendix III groundwater quality data were evaluated using an interwell approach that statistically compares constituent concentrations at downgradient monitoring wells to those present at background monitoring wells. For the AVS, monitoring wells MW-18(S) and MW-19(S) are designated as background wells because they are located upgradient of the Ash Landfill, whereas the remaining monitoring wells [MW-15(S), MW-16(S), MW-17(S), and MW-20(S)] are located downgradient of the facility.

Prediction limits (i.e., parametric or nonparametric) with retesting were developed for each constituent based on the frequency of non-detect values and whether the background data for that constituent exhibited a normal, lognormal, or nonparametric distribution. For the statistical analysis, non-detect values were represented as one-half the detection limit. No outliers were identified in the background data. Analytical data from the background monitoring wells collected between July 2016 and October 2019 were used to develop an upper prediction limit (UPL), and a lower prediction limit (LPL) for pH, for the Appendix III background data at 95 percent confidence. Data from the downgradient monitoring wells for the same time period were compared to the UPL to identify SSIs over background. Mann-Kendall trend analysis was used to identify statistically significant increasing trends for constituents with SSIs. ProUCL Version 5.1 was used to store the background data and run the statistical analyses. The results of the analyses, including the UPLs, are provided in **Table 1**.

Based on these results, Assessment Monitoring is not required at the AVS CCR Landfill, and Detection Monitoring should continue in 2020.

4. General Information

The following subsections summarize any problems encountered in the AVS CCR program through 2019, any resolutions to those problems, if needed, and upcoming actions planned for 2020.

Program Transitions 2019

There were no groundwater monitoring program transitions for the AVS CCR Landfill monitoring system in 2019.

Problems Encountered

No problems were encountered during the 2019 monitoring period.

Actions Planned for 2020

Basin plans on continuing the Detection Monitoring program for the AVS CCR Landfill in 2020. The Detection Monitoring program will include semi-annual groundwater sampling events and the required statistical evaluations.

5. Summary and Conclusions

AECOM, on behalf of Basin, conducted two rounds of CCR groundwater Detection Monitoring at the AVS CCR Landfill in 2019. The results were used to establish background groundwater quality for Appendix III constituents in the uppermost aquifer, identify appropriate UPLs, and determine whether any UPLs were exceeded at statistically significant levels (SSLs) downgradient of the CCR unit at AVS.

The statistical analysis results indicate that none of the Appendix III constituents had SSIs over background or statistically significant increasing trends in constituent concentrations. Based on these results, Assessment Monitoring is not required at the AVS. Detection Monitoring will continue at the site in 2020.

6. References

AECOM. 2017. CCR Groundwater Monitoring System Report, Antelope Valley Station, Beulah, North Dakota. Basin Electric Power Cooperative. October 2017.

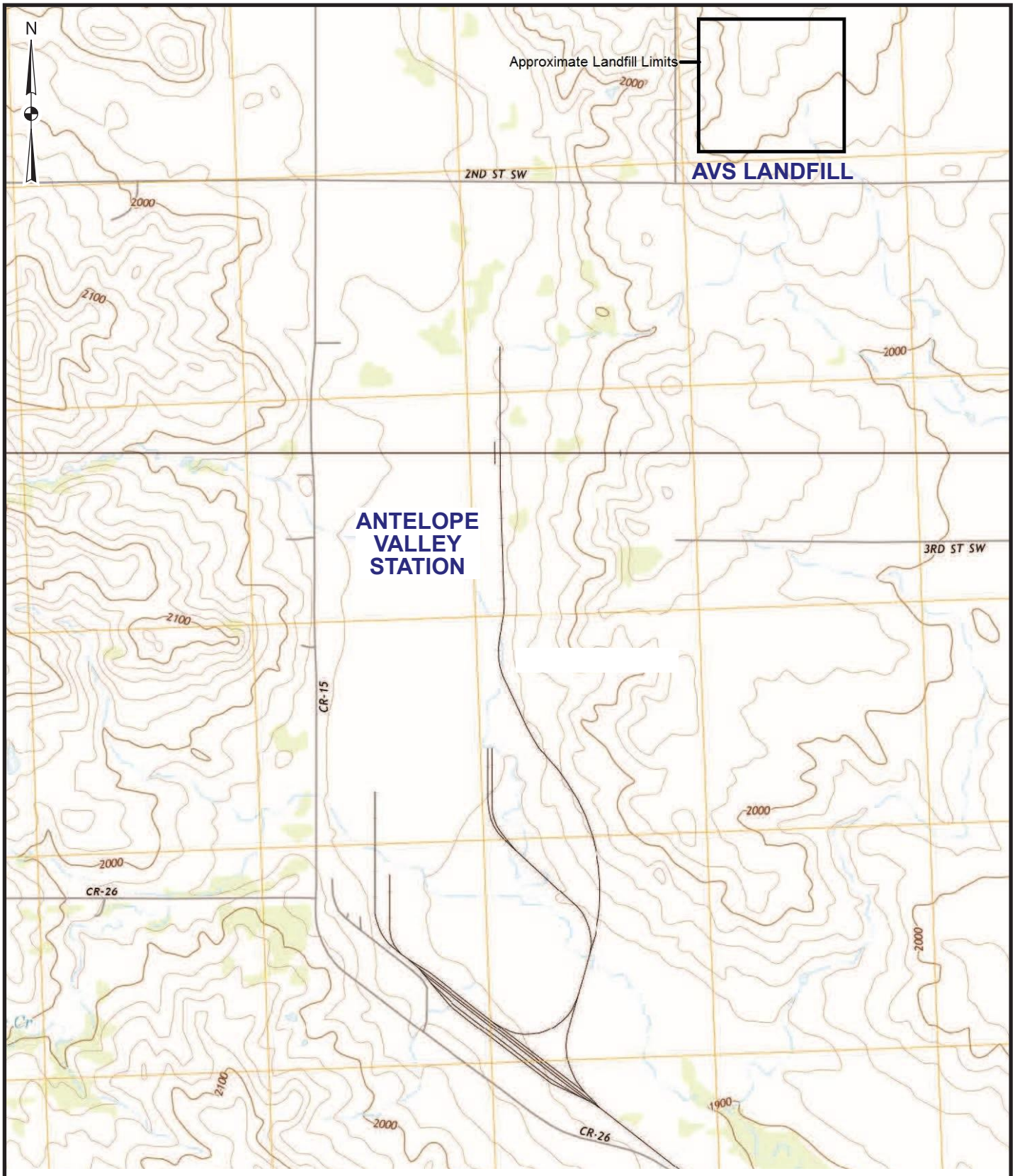
AECOM. 2018a. Sampling and Analysis Plan, CCR Monitoring Program, Antelope Valley Station, Beulah, North Dakota. Basin Electric Power Cooperative. January 2018.

AECOM. 2018b. First Annual Groundwater Monitoring and Corrective Action Report, 2016-2017, Antelope Valley Station, Beulah, North Dakota. Basin Electric Power Cooperative. January 2018.

AECOM. 2019. Second Annual Groundwater Monitoring and Corrective Action Report, Antelope Valley Station, Beulah, North Dakota. Basin Electric Power Cooperative. January 2019.

U.S. Environmental Protection Agency. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance. EPA 530-R-09-007. March 2009. 884 pp.

Figures



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0 2,000 4,000

APPROXIMATE SCALE IN FEET

ND

Quadrangle Location

BASE MAP SOURCE: USGS 7½ minute topographic quadrangle maps: Beulah, North Dakota 2014; Beulah NE, North Dakota 2014.

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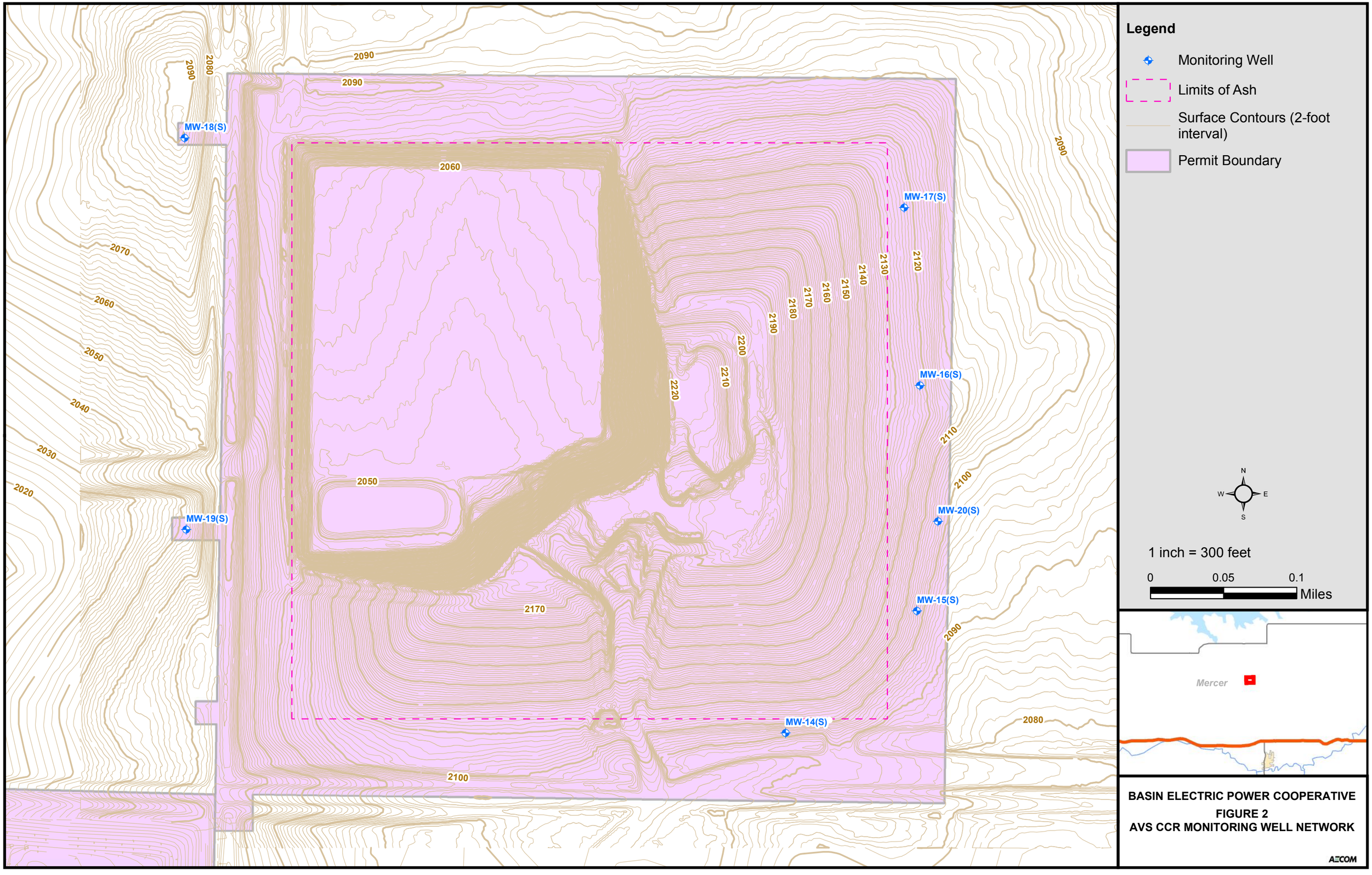
FIGURE 1
SITE LOCATION MAP
ANTELOPE VALLEY STATION LANDFILL

AECOM



Legend

- Monitoring Well
- Limits of Ash
- Surface Contours (2-foot interval)
- Permit Boundary

N
W E
S

1 inch = 300 feet

0 0.05 0.1 Miles

BASIN ELECTRIC POWER COOPERATIVE
FIGURE 2
AVS CCR MONITORING WELL NETWORK

AECOM

Table

Table 1. AVS CCR Landfill Statistical Analysis Methods and Background Upper Prediction Limits

Parameter (Units)	Number of Samples	Percent Nondetects	Normal or Lognormal Distribution?	Statistical Method	Background Limit
Boron (mg/L)	25	60	No/No	Nonparametric 95% UPL	0.20
Calcium (mg/L)	25	0	No/Yes	Parametric 95% UPL	19
Chloride (mg/L)	25	20	No/No	Nonparametric 95% UPL	26
Fluoride (mg/L)	25	20	No/No	Nonparametric 95% UPL	4.3
pH (std units)	29	0	Yes/Yes	Parametric 95% UPL/LPL	9.97/6.71
Sulfate (mg/L)	25	0	No/No	Nonparametric 95% UPL	697
TDS (mg/L)	25	0	No/No	Nonparametric 95% UPL	2,083

Note pH has both an LPL and UPL; all other constituents only have an UPL.

Attachment A
Sampling and Analysis Report, 2019

AECOM Imagine it. Delivered.

2019 Sampling and Analysis Report AVS Landfill CCR Monitoring Program

Antelope Valley Station
Beulah, North Dakota

Basin Electric Power Cooperative

January 31, 2020

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List of Acronyms

AECOM	AECOM Technical Services, Inc.
AVS	Antelope Valley Station
Basin	Basin Electric Power Cooperative
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
EPA	United States Environmental Protection Agency
QA/QC	Quality assurance/quality control

1. Introduction

On behalf of Basin Electric Power Cooperative (Basin), AECOM Technical Services, Inc. (AECOM) prepared this Coal Combustion Residuals (CCR) Groundwater Sampling and Analysis Report for the Basin Antelope Valley Station (AVS) CCR Landfill. The objective of the report is to provide a description of the field and office activities performed in 2019 in support of the AVS CCR Landfill groundwater monitoring program.

This Sampling and Analysis Report was prepared to present the results of sampling and analysis of groundwater conducted for the monitoring requirements of the United States Environmental Protection Agency (EPA) CCR rule (Chapter 40 of the Code of Federal Regulations (CFR), Sections 257.90 to 257.98). Specifically, the report presents the data collected for the two groundwater Detection Monitoring events conducted in 2019.

2. Groundwater Flow

As required by 40 CFR Section 257.93(c), groundwater elevations were measured in each well prior to purging each time groundwater was sampled. The measurements, presented in **Table 1**, were used to create potentiometric surface maps for the uppermost aquifer for the Detection Monitoring events. The resulting potentiometric surface maps were used to evaluate the direction of groundwater flow and hydraulic gradient for the subject CCR unit. **Figure 1** and **Figure 2** represent potentiometric surface maps constructed using measurements taken on May 21, 2019 and October 16, 2019 respectively, and shows inferred groundwater flow directions for the CCR unit. These potentiometric maps illustrate groundwater flow patterns that are generally consistent with the patterns observed during previous monitoring events. Calculated groundwater flow velocities are summarized in **Table 2**.

Based on the groundwater flow conditions documented in this chapter, the relative function of the monitoring wells employed in the AVS CCR Landfill groundwater monitoring system are as follows:

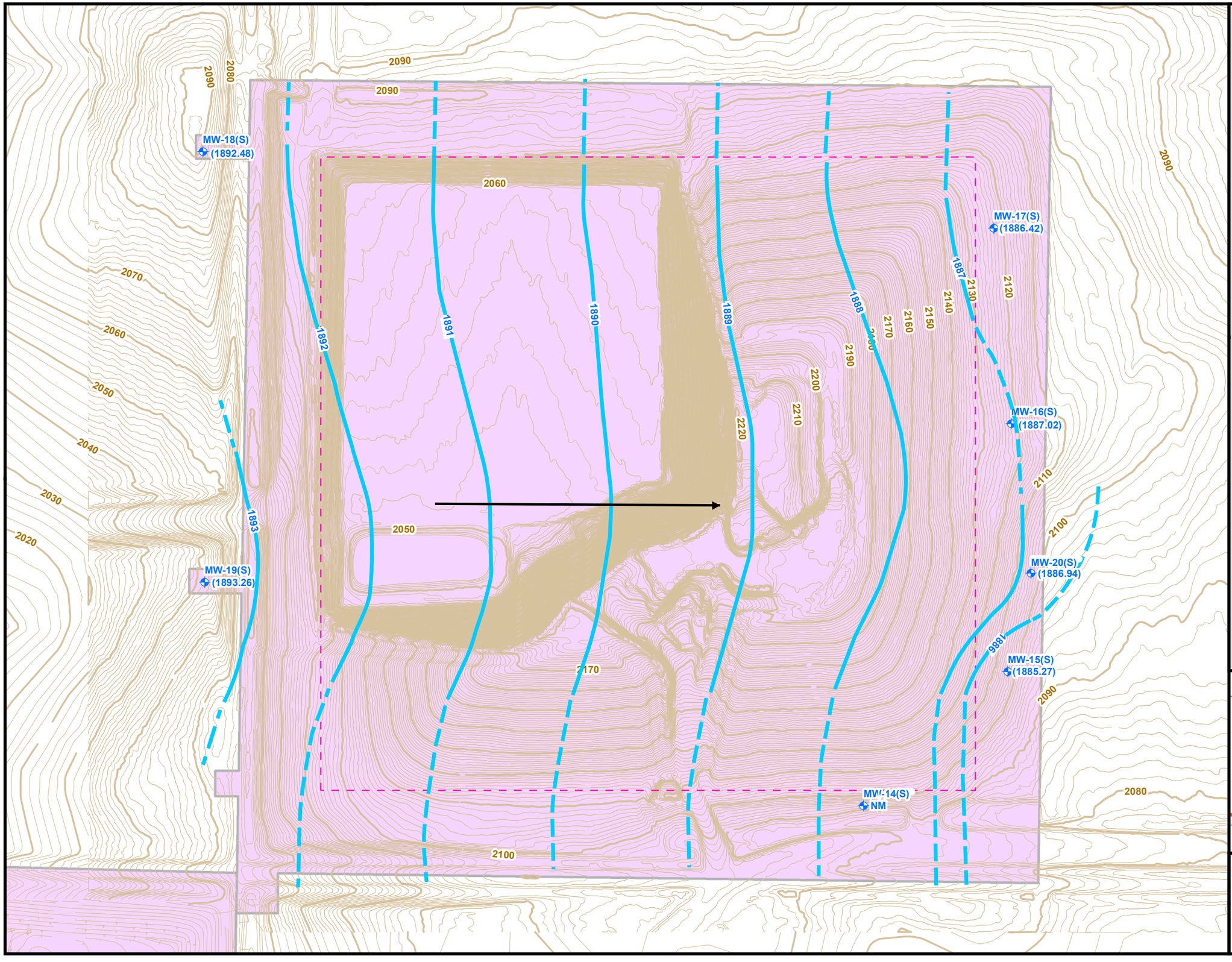
CCR unit	Background wells	Downgradient wells
Landfill	MW-18(S), MW-19(S)	MW15(S), MW-16(S), MW-17(S), MW-20(S)

Monitoring well MW-14(S) is being excluded from the groundwater monitoring network due to insufficient water production to obtain a representative sample. However, it remains in place for collection of groundwater level measurements for potential use in potentiometric mapping as appropriate.

3. Groundwater Quality

The analytical testing laboratory provided reports presenting the results of laboratory analysis for each monitoring event. These laboratory reports are included in the operating record and were reviewed for completeness against the project-required methods and the chain-of-custody forms. Laboratory reports were also reviewed for holding times, and that the data was appropriately flagged based on the quality assurance/quality control (QA/QC) testing results provided by the laboratory. The results were compiled into summary form as presented in **Table 3**.

Figures



Legend

- Monitoring Well
- (1886.42) Groundwater Elevation (feet, above mean sea level)
- Limits of Ash
- Surface Contours (2-foot interval)
- Permit Boundary
- Piezometric Surface Contour (1-foot interval) dashed where inferred
- Groundwater Flow Direction

N
W E
S

1 inch = 300 feet

0 0.05 0.1 Miles

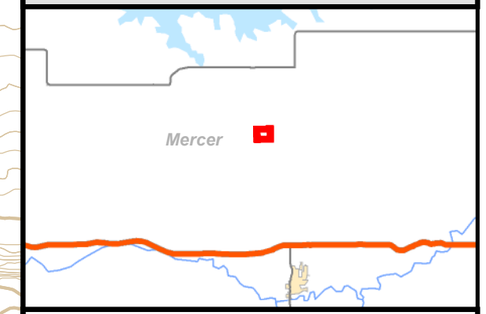


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FIGURE 1
AVS CCR MONITORING WELL NETWORK
POTENTIOMETRIC SURFACE MAP
May 21, 2019

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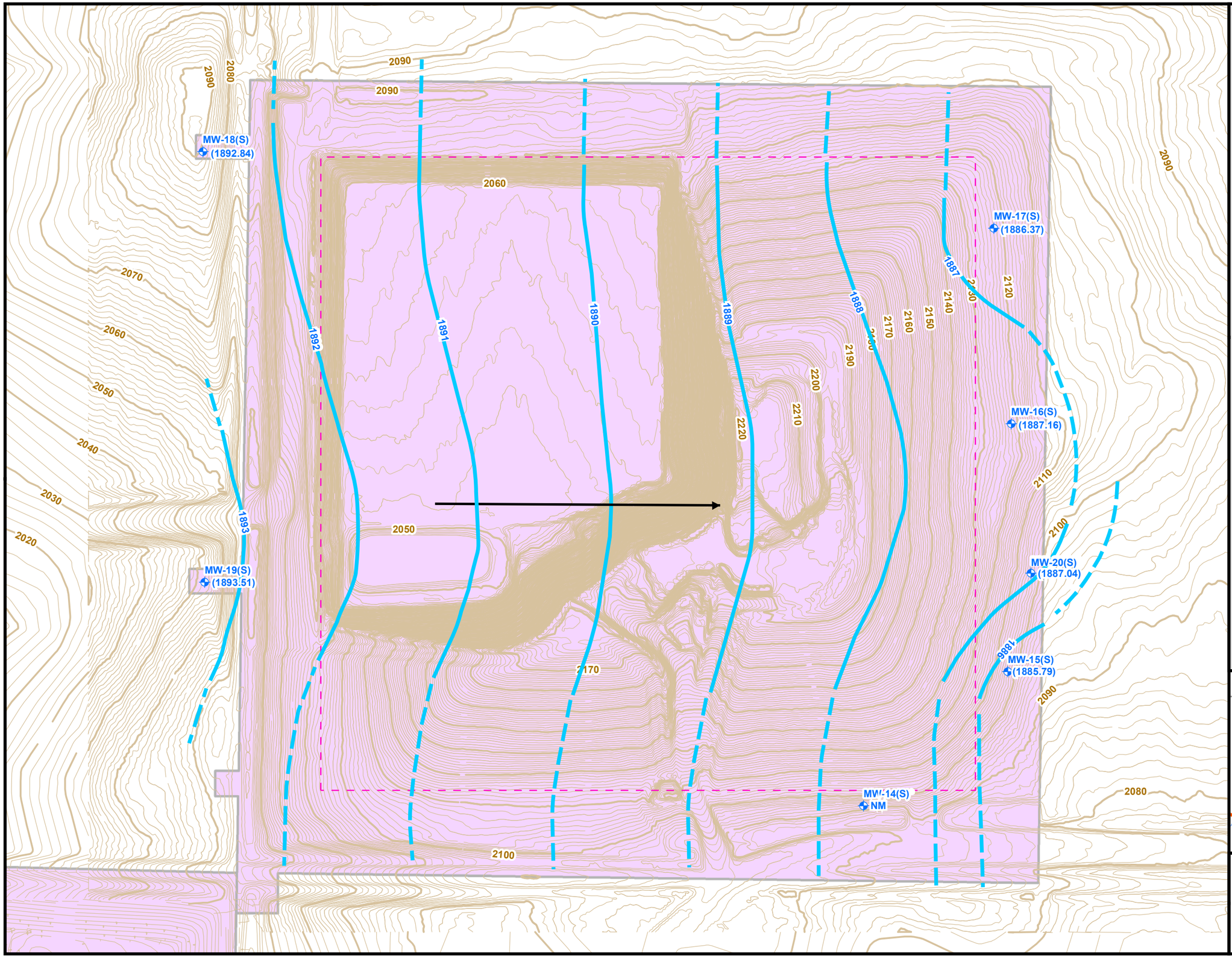


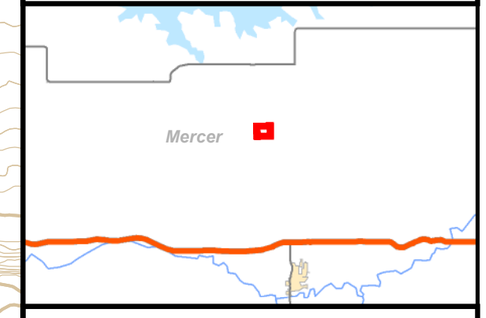
Legend

- Monitoring Well
- (1886.37) Groundwater Elevation (feet, above mean sea level)
- Limits of Ash
- Surface Contours (2-foot interval)
- Permit Boundary
- Piezometric Surface Contour (1-foot interval) dashed where inferred
- Groundwater Flow Direction

N
W E
S

1 inch = 300 feet

0 0.05 0.1 Miles



BASIN ELECTRIC POWER COOOPERATIVE
FIGURE 2
AVS CCR MONITORING WELL NETWORK
POTENTIOMETRIC SURFACE MAP
October 16, 2019

AECOM

Tables

TABLE 1

2019 GROUNDWATER MONITORING WATER LEVELS AND ELEVATIONS
CCR PROGRAM MONITORING WELLS
ANTELOPE VALLEY STATION CCR LANDFILL- BEULAH ND

Well ID	Reference Elevation Top of Casing* (feet, NAVD 88)	May 21, 2019 Depth to Water (feet)	Groundwater Elevation (feet, NAVD 88)	October 16, 2019 Depth to Water (feet)	Groundwater Elevation (feet, NAVD 88)
MW-14(S)	2093.54	Not Measured	Not Measured	Not Measured	Not Measured
MW-15(S)	2104.89	219.32	1885.57	219.10	1885.79
MW-16(S)	2123.70	236.68	1887.02	236.54	1887.16
MW-17(S)	2125.06	238.64	1886.42	238.69	1886.37
MW-18(S)	2091.70	199.08	1892.62	198.86	1892.84
MW-19(S)	2042.68	149.42	1893.26	149.17	1893.51
MW-20(S)	2107.57	220.63	1886.94	220.53	1887.04

TABLE 2

ESTIMATED GROUNDWATER GRADIENT AND SEEPAGE VELOCITY
CCR PROGRAM MONITORING WELLS
ANTELOPE VALLEY STATION CCR LANDFILL – BEULAH, NORTH DAKOTA

Date of event	d_l (ft)	d_h (ft)	i (ft/ft)	n_e	K (ft/day)	v_s (ft/day)
7/13/2016	1050	3	2.86E-03	0.185	0.234	3.62E-03
2/22/2017	1140	3	2.63E-03	0.185	0.234	3.33E-03
3/21/2017	1020	2	1.96E-03	0.185	0.234	2.48E-03
4/19/2017	1050	3	2.86E-03	0.185	0.234	3.62E-03
5/23/2017	1230	3	2.44E-03	0.185	0.234	3.09E-03
6/28/2017	1020	3	2.94E-03	0.185	0.234	3.72E-03
7/24/2017	1110	3	2.70E-03	0.185	0.234	3.42E-03
8/16/2017	1410	3	2.13E-03	0.185	0.234	2.69E-03
4/25/2018	1260	3	2.38E-03	0.185	0.234	3.01E-03
10/10/2018	1245	3	2.41E-03	0.185	0.234	3.05E-03
5/21/2019	1425	3	2.11E-03	0.185	0.234	2.66E-03
10/16/2019	1500	3	2.00E-03	0.185	0.234	2.53E-03

d_l = Horizontal separation between upgradient and downgradient locations perpendicular to potentiometric contours

d_h = Change in hydraulic head between upgradient and downgradient locations

i = Hydraulic gradient (change in elevation over distance)

n_e = Site average porosity of 18.5%

K = Site average hydraulic conductivity of 2.34 E-01 ft/day from slug and pumping tests at site

v_s = Seepage Velocity (ft/day)

Hydraulic Gradient Governing Equation[1] – $$i = -dh/dl$$

Seepage Velocity Governing Equation[2] – $$v_s = -K * i / n_e$$

Table 3

2019 Analytical Results Summary
AVS Landfill
Antelope Valley Station - Beulah, North Dakota

			Appendix III Constituents						
Well ID	Event	Date	Boron mg/L	Calcium mg/L	Chloride mg/L	Fluoride mg/L	pH SU	Sulfate mg/L	Total Dissolved Solids mg/L
MW-15(S)	First Half 2019	5/21/19	0.137	5.14	15.8	1.19	7.7	268	1850
MW-16(S)	First Half 2019	5/21/19	0.143	5.71	16.9	1.2	7.83	105	1610
MW-17(S)	First Half 2019	5/21/19	0.159	5.98	14.4	1.16	7.86	229	1860
MW-18(S)	First Half 2019	5/21/19	0.136	9.85	7.99	2.06	8.89	282	1210
MW-19(S)	First Half 2019	5/21/19	0.147	4.02	13.1	0.605	7.38	683	2110
MW-19(S) Dup	First Half 2019	5/21/19	0.141	3.91	13.1	0.622		680	2060
MW-20(S)	First Half 2019	5/21/19	0.146	5.69	26.2	1.11	7.42	82.3	1860
MW-15(S)	Second Half 2019	10/16/19	0.132	4.65	14.6	1.05	8.19	230	1800
MW-16(S)	Second Half 2019	10/16/19	0.136	5.08	15.7	1.07	7.95	109	1620
MW-17(S)	Second Half 2019	10/16/19	0.142	4.97	13.8	1.01	8.02	183	1770
MW-18(S)	Second Half 2019	10/16/19	0.127	9.56	6.31	1.6	9.33	263	1230
MW-19(S)	Second Half 2019	10/16/19	0.144	3.97	12.7	0.532	8.37	666	2020
MW-19(S) Dup	Second Half 2019	10/16/19	0.138	3.79	12.7	0.534		657	1980
MW-20(S)	Second Half 2019	10/16/19	0.138	5.26	24.8	0.953	7.61	79.4	1800

TDS = Total Dissolved Solids
mg/L = milligrams per liter
S.U. = Standard units
pCi/L = picoCurie/liter