



Tennessee Valley Authority
Kingston Fossil Plant
Ash Disposal Area (IDL 73-0094)

GROUNDWATER DETECTION MONITORING REPORT JUNE 2014

Prepared by

Amos L. Smith, PG

Chattanooga, Tennessee
August 4, 2014

DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information.

Brian D. Keeling, Kingston Fossil Plant Manager
August 5, 2014

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INTRODUCTION

This report contains groundwater compliance monitoring results for samples collected on June 10-11, 2014, from the four designated monitoring wells surrounding the Kingston Fossil Plant (KIF) Ash Disposal Area. These data represent the latest set of semi-annual detection monitoring results for the facility. Groundwater samples were analyzed by Test America, located in Nashville, TN. Sample collection and laboratory analyses were performed in accordance with Tennessee Department of Environment and Conservation (TDEC) Rule 0400-11-01-.04(7) and the facility groundwater monitoring plan approved by TDEC (September 2006).

GROUNDWATER SAMPLING

Groundwater sampling was performed by W.F. Nichols (TVA) at upgradient well AD-1 and downgradient wells AD-3, 6AR, and 22. Wells were in good physical condition. Each has either a concrete protective ring or concrete filled bollards to prevent impact from nearby heavy equipment operations. Non-dedicated bladder pumps were used to purge and sample all monitoring wells. Duplicate samples and matrix spikes for QA/QC purposes were collected from monitoring well AD-1. An equipment blank was collected after well AD-1 but before sampling well AD-3. Field parameters (i.e., temperature, specific conductance, pH, dissolved oxygen, and oxidation-reduction potential) were monitored during well purging using a flow-through cell and calibrated instruments.

Wells were purged by low-flow sampling to reduce turbidity, as authorized by Mr. David Fugate (TDEC) during a phone call with TVA's Mike Tritapoe on September 11, 2009. Low-flow sampling involves pumping from the well at a rate that equals inflow of groundwater into the screen, then sampling after three consecutive five-minute intervals show stable readings of field parameters. Field data sheets are included in Appendix A. Samples were contained in new sample bottles provided by the laboratory with appropriate preservatives, where applicable. The samples were then sealed, labeled, recorded on a custody form, and placed in an iced cooler for transport. Samples were delivered to Test America within two days of sampling (June 13, 2014). A copy of the sample custody form is given in Appendix B.

ANALYTICAL RESULTS

Groundwater samples were analyzed for the 17 required inorganic constituents specified in Appendix I of TDEC Rule 0400-11-01.04. Laboratory analyses were completed by July 31, 2014, and are summarized in Table 1. The laboratory reports presented in Appendix C include analytical methods and detection limits for each constituent. Constituent concentrations reported for all samples were below TDEC maximum contaminant levels (MCLs). All required Appendix I inorganic constituents were below reporting limits in the equipment blank. All analytical testing was performed within recommended sample holding times.

STATISTICAL EVALUATION OF DETECTION MONITORING RESULTS

Evaluation of monitoring data was performed in accordance with requirements outlined in TDEC Rule 0400-11-01-.04(7)(a)(5). This facility was analyzed by intrawell analysis of well results from June 2005 to December 2009. Since June 2010, the facility has been analyzed by interwell analysis.

Prediction interval methods applied on an interwell basis were used for statistical evaluation of the June 2014 groundwater detection monitoring data. In general, one-sided upper prediction limits (UPLs) derived from n background measurements and having a $(1-\alpha)$ probability of including at least one of two future measurements at compliance wells are computed for each constituent using the methodology of Gibbons (1994, pp. 8-76), where α is the Type 1 (false-positive) error level. Future sample constituent measurements from compliance wells associated with each aquifer are compared to background prediction limits derived from available monitoring data for the same aquifer. The methodology dictates that if any new measurements exceed the background UPL, one independent confirmation sample is collected from each monitoring well having a statistical exception. Confirmation samples are analyzed only for the exceeded constituents. If the resample also exceeds the UPL, the exceedance would be deemed statistically significant; otherwise, the original UPL exceedance would be considered insignificant. Any observed UPL exceedance that is consistent with historical values may or may not have confirmation sampling performed, depending on the assumption of confirmation.

Implementation of the prediction interval analysis is performed using the MANAGES groundwater data management and analysis software (EPRI, 2014). The appropriate form of the prediction interval method, i.e., either parametric or nonparametric, is selected for each constituent based on background data normality and the percentage of nondetectable values. Background constituent data which are either normally or log-normally distributed (based on Shapiro-Wilk testing at the 95% confidence level) are evaluated with parametric prediction intervals. Otherwise, the non-parametric form of the prediction interval is applied.

The parametric and nonparametric forms of prediction intervals used in the analysis comply with performance standards specified in 0400-11-01-.04(7)(a)4(vi). A site-wide Type 1 error rate of 0.05 is maintained in application of the parametric prediction interval method. The corresponding individual sample constituent confidence levels ($1-\alpha$) for comparisons are computed and reported by MANAGES based on the number of compliance locations, constituents, and confirmation samples using the methodology presented in the American Society for Testing and Materials (ASTM) D6312-98 (ASTM, 2012). For nonparametric prediction interval testing, the confidence level is based on the number of background sample data and the number of confirmation samples.

Upper prediction limits (UPL) for Appendix I constituents presented in Table 1 were computed using historical background data for upgradient well AD-1 collected between June 11, 2009, and June 10, 2014. The statistical analysis results for the June 2014 groundwater monitoring event are presented in Table 1 and indicate initial exceedances of the UPL for concentrations of arsenic (in wells AD-3 and 22), cadmium (in well 6AR), cobalt (in wells AD-3 and 6AR), nickel (in well 6AR), vanadium (AD-2, AD-3, well 22) and zinc (in well 6AR).

Initially, Test America reported data with levels of vanadium in excess of the site UPL. A reanalysis was requested and the subsequent and final report indicated levels of vanadium in all three down gradient wells at very similar levels slightly above the reporting limit. Since this constituent does not have a history of being detected at this site, and since the detections were similarly reported just above the reporting limit (RL), laboratory error resulting in false detections of this constituent is possible and confirmation resampling was decided to be unwarranted. However, laboratory results for vanadium will be closely examined following the next sampling event to determine if a trend is developing and additional sampling is warranted.

Concentrations of metals in well 6AR have been slightly elevated since the first sampling event in September 2009, which could be attributed to naturally-occurring metals associated with alluvial deposits surrounding the well screen. Bottom ash, which was not identified in the lithological boring log of this well but is present at a number of neighboring borings, might also be a source for these elevated constituents. Examination of the field data sheets indicates turbidity in wells at this site can be problematic. Initial turbidity values noted in several wells was extremely high but decreased during well purging with final reported values during sampling and laboratory measurements of total suspended solids (TSS) being relatively low, however, turbidity at well 6AR did exceed EPA drinking water standards. Since the facility wells are installed in alluvial sediment, which can contain high levels of the naturally occurring metal constituents, TVA believes that a higher turbidity value and/or elevated TSS values reflects the potential to impact / elevate the metal concentrations detected in groundwater samples collected from the facility wells.

Table 1. June 10-11, 2014 Groundwater Monitoring Results

Constituent	Units	AD-1	6AR	AD-3	22	Upper Prediction Limit (UPL) ^a	Comparison to UPL ^b			MCL ^c
		upgradient	downgradient	downgradient	downgradient		6AR	AD-3	22	
Antimony	µg/L	<2	<2	<2	<2	2	L	L	L	6
Arsenic	µg/L	<2	<2	2.57	2.84	2	L	G	G	10
Barium	µg/L	54.4	<100	44.7	32	102	L	L	L	2000
Beryllium	µg/L	<2	<2	<2	<2	2	L	L	L	4
Cadmium	µg/L	<1	2.48	<1	<1	1	G	L	L	5
Chromium	µg/L	<2	<2	<2	<2	4.35	L	L	L	100
Cobalt	µg/L	<2	117	4.99	<2	2	G	G	L	N/A
Copper	µg/L	<2	<2	<2	<2	15.1	L	L	L	N/A
Fluoride	mg/L	0.214	<0.1	0.197	<0.1	0.389	L	L	L	4
Lead	µg/L	<2	<2	<2	<2	2	L	L	L	15
Mercury	µg/L	<0.2	<0.2	<0.2	<0.2	0.2	L	L	L	2
Nickel	µg/L	<2	41.9	<2	<2	5.31	G	L	L	100
Selenium	µg/L	<2	<2	<2	<2	2	L	L	L	50
Silver	µg/L	<2	<2	<2	<2	2	L	L	L	180 ^d
Thallium	µg/L	<2	<2	<2	<2	2	L	L	L	2
Vanadium	µg/L	<2	2.55	2.56	2.63	2	G	G	G	N/A
Zinc	µg/L	<25	35.6	<25	<25	25	G	L	L	N/A
Total Suspended Solids	mg/L	<1	3.5	1.4	1.6					
Turbidity	NTU	3.3	9.5	0.9	3.4					

a - Upper prediction limit calculated based on background data from June 11, 2009, to June 10, 2014.

b - "L" = less than or equal to UPL, "G" = greater than UPL.

c - TDEC MCL from Rule 0400-11-01-.04, Appendix III (March 2013); N/A indicates constituents without a TDEC MCL

d - Site specific groundwater protection standard approved 2/15/07.

Monitoring wells were not resampled for constituents exceeding statistical limits to confirm initial UPL exceedances, since the results are consistent with historical values or, in the case of vanadium, laboratory issues are suspected. Construction activities in the immediate vicinity of well 22, include drilling and grouting involved with slurry wall construction. These activities may have temporarily influenced groundwater conditions in the vicinity of well 22 during the December 2013 and June 2014 sampling events, potentially causing anomalous results. Given the June 2014 detections did not appear to be part of an increasing trend, as well as the potential influence of ongoing construction temporarily affecting the wells, resampling did not appear warranted at this time. The next scheduled compliance event for wells AD-1, AD-3, 6AR, and 22 is planned for December 2014.

HYDROGEOLOGIC CONDITIONS

The Kingston plant site is located in the Valley and Ridge physiographic province of the Appalachian Highlands region. This region is characterized by a sequence of long narrow ridges and valleys trending northeast-southwest. In general, ridges are formed by relatively resistant sandstone, limestone, and dolomite units while the valleys are underlain by soluble limestone and easily weathered shale. The controlling structural feature of the site is a series of northeast-striking thrust faults which has forced older Cambrian and Ordovician rocks over younger units. Bedrock dips southeast at angles ranging from a few degrees to about 90 degrees.

The ash pond area is immediately underlain by Quaternary alluvium ranging in thickness from about 1.5 m along a portion of the northern perimeter of the site to a maximum of 20 m on the western boundary. The alluvial deposits are unconsolidated and lenticular, and consist of clay, silt, and sand with occasional gravel. A thin layer of residuum is occasionally present directly above bedrock. The residuum is typically composed of clay and silt with weathered fissile shale fragments.

Bedrock beneath the alluvial deposits at the disposal site is primarily represented by the Conasauga Group (middle to upper Cambrian age). The only exception is a small area along the northern margin of the site underlain by the Rome formation (lower Cambrian age). Specific geologic units within the Conasauga Group represented at the site include the Nolichucky, Maryville, Rogersville, Rutledge, and Pumpkin Valley formations. These formations are locally of low water-producing capacity, and predominantly consist of shale with interbedded siltstone,

limestone, and conglomerate. Total thickness of the Conasauga Group beneath the site is unknown but is estimated to be approximately 450 meters. The Rome formation is generally composed of interbedded shale, sandstone, and siltstone. The elevation of the top of rock in the ash pond area is relatively uniform, varying from approximately 213 to 218 m-MSL. Outside this area the bedrock surface rises steeply to the west and southwest. The lower bedrock terrace corresponding to the disposal area represents an erosion surface associated with the ancestral Emory River.

Groundwater movement at the site generally follows topography with groundwater flowing eastward and southeastward from Pine Ridge toward the Emory River. Groundwater originating on, or flowing beneath, the ash pond area ultimately discharges to the reservoir without traversing private property. This shallow aquifer is not utilized as a source for drinking water.

Groundwater levels measured in site monitoring wells June 10-11, 2014, immediately prior to any sampling of wells that day are presented in Table 2. The shallow groundwater potentiometric surface derived from these measurements is shown on Figure 1. Groundwater generally flows southeastward across the ash disposal area toward the reservoir. An average hydraulic gradient of approximately 0.0073 m/m is estimated between the western and eastern boundaries of the disposal area. The alluvial aquifer underlying the ash disposal area exhibits a mean horizontal hydraulic conductivity of 0.006 m/d. The local Darcy flux is therefore estimated to be approximately 4.4×10^{-5} m/d.

Table 2. Groundwater Levels Measured June 10-11, 2014

	Top of Casing Elevation (m)	Depth to Water (m)	Water Elevation (m-msl)	Well Bottom Depth (m)
AD-1	237.74	2.58	235.16	10.85
AD-3	229.13	2.54	226.59	5.64
6AR	229.27	4.78	224.49	11.72
22	231.12	5.25	225.87	14.10

**Top of casing elevation information for well 22 was refined since the December 2009 report. Raising of the road neighboring the well required a commensurate elevation in the well casing.*

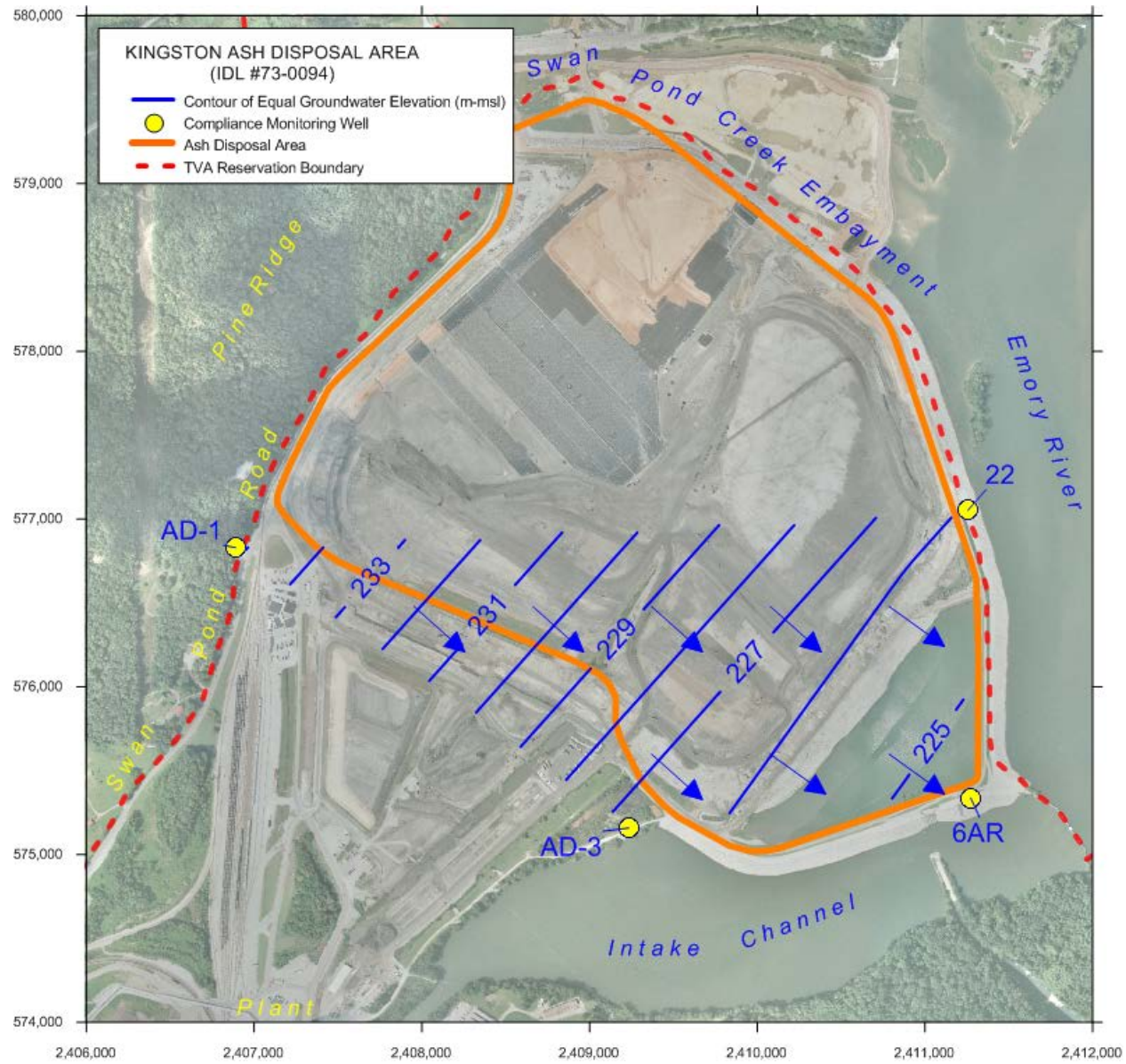


Figure 1. Groundwater Potentiometric Surface June 10-11, 2014

CONCLUSIONS

Groundwater analytical data for the June 9-11, 2014, monitoring event showed concentrations of the 17 Appendix I inorganic constituents were below MCLs in all samples. Statistical exceedances of background UPL were observed for arsenic (in wells AD-3 and 22), cadmium (in well 6AR), cobalt (in wells AD-3 and 6AR), nickel (in well 6AR), vanadium (AD-2, AD-3, well 22) and zinc (in well 6AR). Results from this event appear consistent with historical values with the exception of the detections of vanadium. Confirmation sampling was not conducted for well 22 since this does not appear to be part of an increasing trend and the potential influence of nearby construction could be temporarily affecting groundwater quality in the area of well 22. Since vanadium has historically not been detected at the site and was reported at a level just slightly above the laboratory reporting limit, a laboratory induced issue is possible. Therefore, TVA proposes to closely evaluate this constituent following the next sampling event to determine if a trend is developing.

Groundwater originating on, or flowing beneath, the ash pond area ultimately discharges to the reservoir without traversing private property. This shallow aquifer is not utilized as a source for drinking water. Examination of the field data sheets indicates turbidity in wells at this site can be problematic. Initial turbidity values noted in several wells was extremely high but decreased during well purging with final reported values during sampling and laboratory measurements of total suspended solids (TSS) being relatively low, however, turbidity at well 6AR did exceed EPA drinking water standards. Since the facility wells are installed in alluvial sediment, which can contain high levels of the naturally occurring metal constituents, TVA believes that a higher turbidity value and/or elevated TSS values reflects the potential to impact / elevate the metal concentrations detected in groundwater samples collected from the facility wells.

The next sampling of the Ash Disposal Area is planned for December 2014.

REFERENCES

- American Society for Testing and Materials (ASTM), 2012. Standard Guide for Developing Appropriate Statistical Approaches for Groundwater Detection Monitoring Programs, D6312-98.
- EPRI, 2014. "MANAGES: Groundwater Data Management and Evaluation Software", Product #1012581, Palo Alto, CA.

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- Tennessee Department of Environment and Conservation (TDEC), Division of Solid Waste Management. *Rule 0400-11-01-.04 Solid Waste Processing and Disposal*. Revised March 2013.
- TVA, 2006. TVA Kingston Fossil Plant Dredge Cell Lateral Expansion Operations Manual, R3 (approved September 12, 1996).

APPENDIX A
FIELD DATA SHEETS

APPENDIX B
SAMPLE CUSTODY RECORD

APPENDIX C
LABORATORY DATA SHEETS

APPENDIX D

GROUNDWATER BACKGROUND DATA – WELL AD-1 HISTORICAL RESULTS

APPENDIX E
DETAILED STATISTICAL ANALYSIS OUTPUT