Dominion Resource Services, Inc.
5000 Dominion Boulevard, Glen Allen, VA 23060
dom.com

August 4, 2016

Ms. Rachel Patton
Department of Environmental Quality
Tidewater Regional Office
5636 Southern Boulevard
Virginia Beach, VA 23462

RE: Nature & Extent/Assessment of Corrective Measures Report
Addendum for Selenium
Chesapeake Energy Center
Landfill Permit No. 440

Dear Ms. Patton:

The enclosed document is a Nature and Extent (N&E)/Assessment of Corrective Measures (ACM) addendum for selenium at the Chesapeake Energy Center (CEC) Industrial Landfill. This document has been prepared pursuant to Virginia Solid Waste Management Regulations (VSWMR) 9VAC20-81-250.C.3.e(a), 9VAC20-81-260.C.1, and Permit Module XI.H.

The CEC Industrial Landfill currently monitors groundwater on a semi-annual basis in accordance with the VSWMR Phase II and corrective action programs. The existing groundwater Corrective Action Plan (CAP) addresses arsenic, beryllium, cobalt, and sulfide in response to previous groundwater protection standard (GPS) exceedances. Selenium is being added to the CAP as a result of a recent detection at a concentration greater than the GPS.

Should you have any questions or comments, please feel free to contact Donald Hintz of Dominion Generation Environmental Services at (804) 273-3552.

Sincerely,

Paula A. Hamel
Director, Generation Environmental Services

Enclosure

cc: Geoff Christe
Geoff.Christe@ deq.virginia.gov

Nature & Extent/Assessment of Corrective Measures Report Addendum for Selenium

Chesapeake Energy Center
Industrial Landfill – Solid Waste Permit No. 440
Chesapeake, Virginia

July 29, 2016

Prepared for:
Dominion Resources Services, Inc.
5000 Dominion Boulevard
Glen Allen, VA 23060
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Prepared by:
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AECOM Project No. 60512684

AECOM

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Introduction

This document is a Nature and Extent (N&E)/Assessment Corrective Measures (ACM) addendum for selenium at the Chesapeake Energy Center (CEC) Industrial Landfill (Solid Waste Permit No. 440). This document has been prepared pursuant to Virginia Solid Waste Management Regulations (VSWMR) 9VAC20-81-250.C.3.e(a), 9VAC20-81-260.C.1, and Permit Module XI.H.

1.1 Background

The CEC Industrial Landfill (the Facility) currently monitors groundwater on a semi-annual basis in accordance with the VSWMR Phase II and corrective action programs. The existing groundwater Corrective Action Plan (CAP) addresses arsenic, beryllium, cobalt, and sulfide in response to previous groundwater protection standard (GPS) exceedances. First semi-annual Phase II sampling in March 2016 confirmed the presence of selenium in well CECW-3 at a concentration greater than GPS. Because selenium is a new GPS exceedance and is not currently included in the CAP, selenium is required to be included in the CAP and N&E characterization and an assessment of corrective measures must be performed.

1.2 Corrective Action History

The Facility entered into the corrective action program in 2002 as the result of arsenic and sulfide GPS exceedances. A *Nature and Extent Study (NES)/Assessment of Corrective Measures (ACM) Report* was prepared by URS Corporation in 2003. A subsequent *Risk Assessment* report was prepared by MACTEC in 2003. A CAP for arsenic was prepared by Groundwater & Environmental Services, Inc. in February 2008 and a revision to the CAP was prepared by AMEC Environmental & Infrastructure, Inc. (AMEC) in 2011. An ACM Addendum report was submitted in 2010 to include beryllium and cobalt and an N&E/ACM addendum to include sulfide was prepared by AMEC in 2011.

The current approved corrective action remedy for arsenic, beryllium, cobalt, and sulfide is adsorption based Monitored Natural Attenuation (MNA). This remedy relies on natural in-situ adsorption of inorganics coupled with long-term geochemical monitoring. As described in the 2011 CAP, metals mobility in the subsurface at the Facility is controlled by formation of precipitates and adsorption onto aquifer minerals. Both of those processes remove dissolved arsenic, beryllium, and cobalt from groundwater. Sulfide is removed by oxidation to sulfate on reaction with low concentration of dissolved oxygen. These physiochemical processes result in natural attenuation that should reduce groundwater metal and sulfide concentrations below the applicable GPS over time.

Geochemical studies performed for the Facility indicate that arsenic adsorption onto minerals is the primary natural attenuation process occurring at the Facility (AMEC, 2011). Studies by AMEC have concluded that sediment and pore water chemistry provide evidence that natural attenuation (adsorption) of arsenic by the subsurface formation of iron oxides and oxyhydroxides is occurring at the Facility (AMEC, 2010). The studies showed that the majority of sediments sampled in the Norfolk Formation at the perimeter of the landfill are oxidized and the upper sands are dominated by iron coated media and iron oxide coated media are actively attenuating arsenic concentrations in pore water.

2.0 Selenium Delineation and Fate and Transport

2.1 Delineation of Selenium in Groundwater

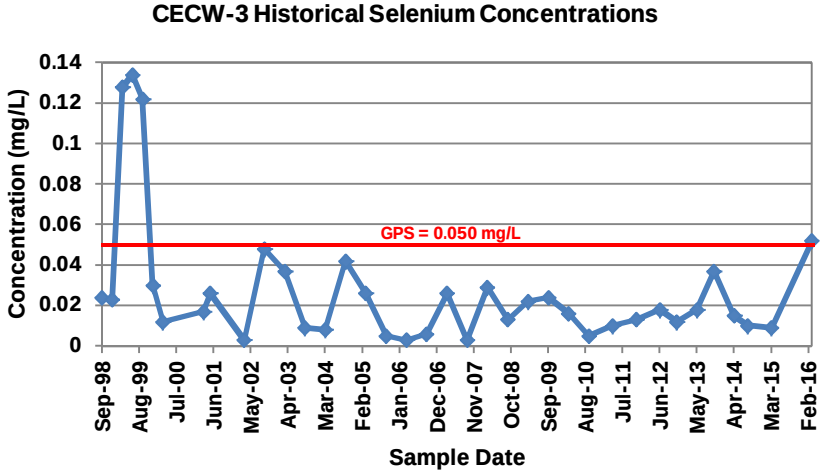
First semi-annual 2016 Phase II compliance groundwater sampling was conducted on March 21 and 22, 2016 in accordance with the Facility Groundwater Monitoring Plan. Initial laboratory results indicated a concentration of total selenium in well CECW-3 of 0.052 milligrams per liter (mg/L), which is greater than the GPS of 0.050 mg/L. Verification sampling of selenium was conducted on May 5, 2016 in well CECW-3 and the verification sampling result (0.244 mg/L) confirmed the initial GPS exceedance.

Total selenium has been monitored in Facility compliance wells on a regular basis since 1994. A summary of historical selenium concentrations is provided in Table 1. Since monitoring of selenium began, only three wells (CECW-3, PO-10, and CECW-6) have had concentrations of selenium above the laboratory quantitation limit (LOQ).

- CECW-3 selenium concentrations ranged from non-detect to 0.134 mg/L in June 1999. Since implementation of GPS in 2002, only the last selenium result collected in March 2016 was found at a concentration above GPS.
- PO-10 selenium concentrations ranged from non-detect to 0.017 mg/L in March 2000. Selenium has not been detected in this well at concentrations above GPS.
- CECW-6 selenium concentrations ranged from non-detect to 0.169 mg/L in December 1999. This well was abandoned in April 2008 due to insufficient water levels. CECW-6I has been used as a replacement well for CECW-6 and has showed no selenium impacts above GPS.

Given the current single selenium GPS exceedance in well CECW-3, it would appear selenium impacts to groundwater are limited to the localized area around this well. Further, groundwater sampling conducted for previous studies at the Facility including the 2003 N&E/ACM and 2011 CAP, did not identify selenium in deep groundwater samples (i.e. CECW-3D) or in other site wells at concentrations close to or above the GPS, with the exception of CECW-3. This confirms that groundwater impacts from selenium are limited to the immediate vicinity of CECW-3 and is not widespread across the site.

Well CECW-3 was installed in 1998 and is located directly adjacent to the waste management unit boundary and adjacent to the bottom ash pond (see Figure 1). The boring log for CECW-3, provided in Appendix A, indicates that this well may be screened in ash material, as was former well CECW-6. This may account for the elevated levels of selenium in these wells. Historical selenium concentrations in well CECW-3 are graphed below.



The above graph indicates that the highest concentrations of selenium in this well were during 1999. This is prior to implementation of low-flow sampling procedures. Once low-flow sampling began in 2000, selenium concentrations averaged 0.017 mg/L, until May 2016. In December 2014, the coal-fired generating units at CEC were retired and the landfill ceased accepting waste. Increased grading and stabilization activities performed while landfill closure approval occurs may have increased turbidity in well CECW-3, which may have affected total metal concentrations in the well.

2.2 Geochemical Behavior of Selenium in the Subsurface

Inorganic species of selenium include:

- Selenide [Se(-II)]
- Elemental selenium [Se(0)]
- Selenite [Se(IV)]
- Selenate [Se(VI)]

Selenide and elemental selenium are insoluble in water, while selenite and selenate are soluble in water. Selenium transport groundwater is affected by pH and the geochemical condition (oxic or reducing conditions). In oxic conditions, transport is dominated by adsorption reactions with aquifer sediments (EPA, 2007). In highly reducing conditions, selenium is attenuated via reduction of selenate and/or selenite to reduced forms upon interaction with biotic/abiotic components of aquifer sediments in the reducing groundwater (EPA, 2007). Reduction to elemental selenium can result in low concentrations of dissolved selenium.

Selenium has the potential of forming precipitates for all its oxidation states, including precipitates with common major cations in groundwater such as calcium, magnesium, iron, and manganese (EPA, 2007). The adsorption of selenium on individual soil minerals is dependent on iron and aluminum oxide surfaces for selenium adsorption onto aquifer sediments and is dependent on pH and the presence of anions that compete for adsorption sites (EPA, 2007).

Conditions that favor the mobility of selenium in the environment are alkaline pH, high selenium concentrations, oxidizing conditions, and high concentration of additional anions that strongly absorb (EPA, 2007). The mobility of selenium depends mainly on which form is present.

2.3 Health Effects of Selenium

Selenium is a naturally occurring element that can be found in rocks and soil. It is not often found in the environment in its elemental form but rather combined with other substances such as sulfide minerals or with silver, copper, lead, and nickel minerals (ATSDR, 2003). In the environment, selenium cannot be created or destroyed, but it can change forms due to weathering of rocks and soil, volcanic eruptions, and burning of fossil fuels. The principal release of selenium into the environment from anthropogenic sources is from coal combustion (ATSDR, 2003). Exposure to selenium near coal burning plants can be from breathing, touching soil, and ingestion of contaminated soil.

Selenium is an essential nutrient for humans and animals. Low level exposure of selenium occurs daily through food, water, and air (ATSDR, 2003). When taken in higher amounts than needed for good health, selenium can be harmful. Acute exposure to high levels of selenium due to oral ingestion produces nausea, vomiting, and diarrhea in both humans and laboratory animals (ATSDR, 2003). Chronic exposure to high levels of selenium due to oral exposure produces selenosis (dermal and neurological effects) in humans.

Water beneath the landfill is not used as a drinking water source and there is no current risk to human or ecological receptors from the impacted groundwater at CECW-3. In addition, it is unlikely that the shallow aquifer would be used as a potable water source in the foreseeable future due to the salinity of the groundwater.

3.0 Conclusions and Recommendations

Selenium has been detected in well CECW-3 at a concentration that exceeds GPS. Based on the well construction/boring log for CECW-3, it would appear that this well is screened in waste material (ash). VSWMR 9VAC20-81-250.A.3 specifies that downgradient monitoring wells should be installed at the disposal unit boundary that ensures detection of groundwater contamination in the uppermost aquifer. As CECW-3 may be screened in waste material, the well does not satisfy VSWMR groundwater monitoring system requirements. As indicated in Dominion's July 2016 update to the Facility's Groundwater Monitoring Plan, CECW-3 will be considered a demonstration well only and will be removed from the groundwater compliance program. In the interim, selenium is required to be added to the Facility's list of contaminants of concern.

Selenium mobility in the subsurface is controlled by the formation of precipitates and adsorption onto aquifer minerals, similarly to arsenic, beryllium, and cobalt. These processes remove these dissolved metals from groundwater via natural processes. Previous studies performed for the Facility have concluded that sediment and pore water chemistry provides evidence that natural attenuation (adsorption) is occurring at the site and that the majority of sediment sampled in the Norfolk Formation at the perimeter of the landfill are oxidized and that the upper sands are dominated by iron-coated media and that iron oxide coated media is actively attenuating arsenic concentrations in pore water. These same processes that are attenuating arsenic are also closely linked to selenium.

The current approved remedy for the Facility (MNA) is already designed to monitor constituents of concern, aquifer conditions, and performance for the absorption based groundwater corrective action. Allowing selenium to fall under the same site wide remediation option as arsenic, beryllium, and cobalt will achieve the CAP objective of managing groundwater beneath the landfill to protect human health and the environment. Also, this goal is consistent with expected future land-use, physical characteristics of the area, groundwater use, and with the remedial goals established within the CAP.

4.0 References

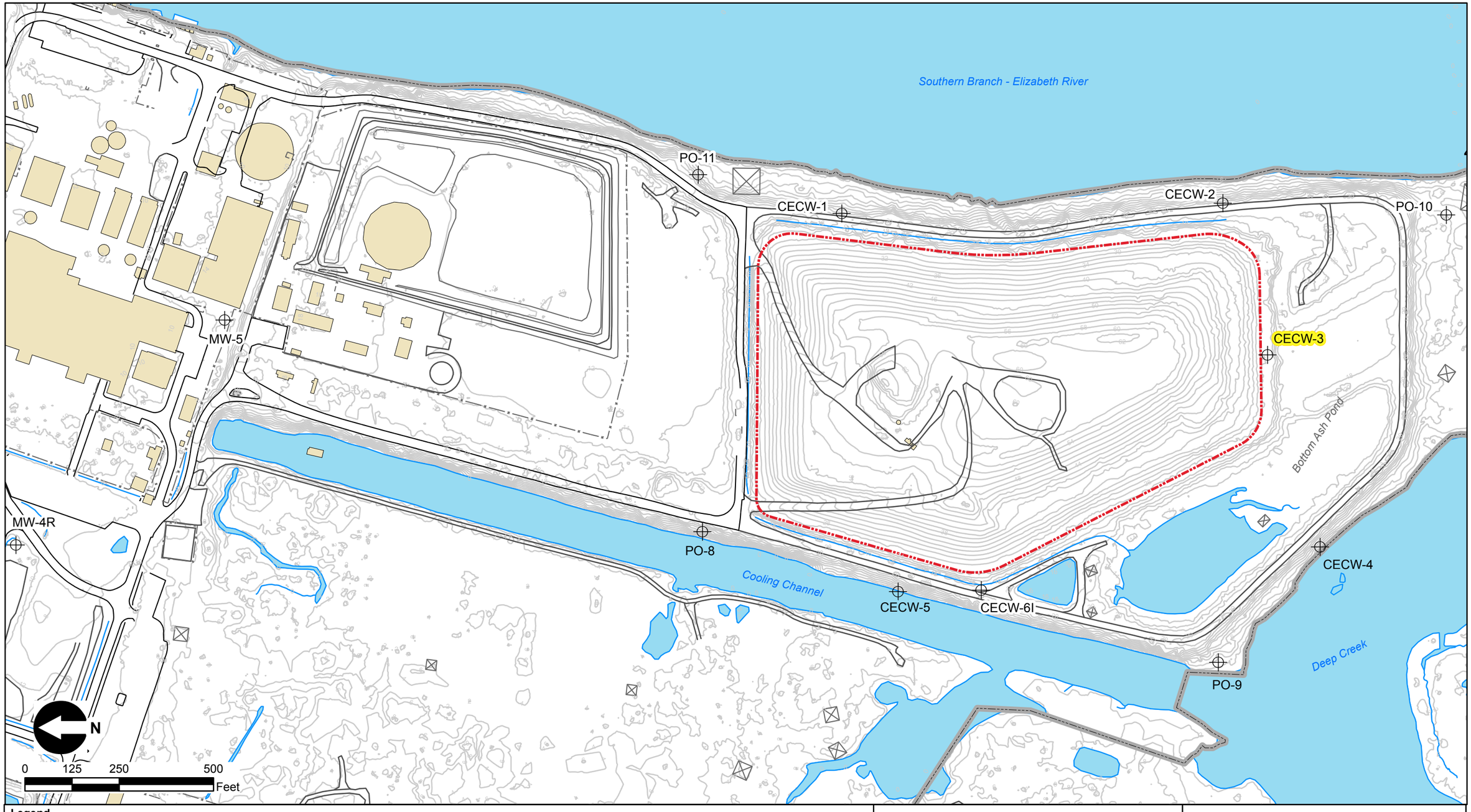
AMEC, 2010. ***Natural Attenuation of Arsenic Demonstration, Chesapeake Energy Center Ash Landfill, Chesapeake, Virginia.*** **June 2010.**

AMEC, 2011. ***Corrective Action Plan – Revision 1, Chesapeake Energy Center Ash Landfill, Chesapeake Virginia.*** **June 2011.**

ATSDR, 2003. Toxicological profile for selenium. Atlanta, GA: Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Public Health Service.

EPA, 2007. ***Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 2– Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium*****. EPA/600/R-07/140, Office of Research and Development, Washington, DC. October 2007.**

FIGURES



Legend

- Property Boundary
- Waste Management Boundary
- Facility Boundary
- Paved Roads and Parking
- Unpaved Roads and Parking
- Monitoring Well
- Structures
- Surface Water
- Topographic Contour

Chesapeake Energy Center - Industrial Landfill
Solid Waste Permit No. 440

Date: July 18,2016	Job Number: 60512684
Prepared By: RIP	Reviewed By: KAH
Scale: 1 inch = 250 feet	File Name: CEC/Figure 1

Figure 1
Facility Layout Map

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TABLES

Table 1
Historical Total Selenium Concentrations - Compliance Wells
Chesapeake Energy Center Industrial Landfill - Permit #440

	Current Compliance WellNetwork													Former Compliance Wells	
Sample Date	**CECW-1**	**CECW-2**	**CECW-3**	**CECW-4**	**CECW-5**	**CECW-6I**	**CECW-10R**	**MW-4R**	**MW-5**	**PO-8**	**PO-9**	**PO-10**	**PO-11**	**CECW-6**	**MW-4**
July-94	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
December-94	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
March-95	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
June-95	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
September-95	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
December-95	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
March-96	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
June-96	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
September-96	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
December-96	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
March-97	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
June-97	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
September-97	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
December-97	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	--	--	<0.003
March-98	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
June-98	--	--	--	--	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
September-98	<0.003	<0.003	**0.024**	<0.003	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
December-98	<0.003	<0.003	**0.023**	<0.003	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
March-99	<0.003	<0.003	**0.128**	<0.003	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
June-99	<0.003	<0.003	**0.134**	<0.003	--	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
September-99	**0.003 J**	<0.003	**0.122**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	**0.027**	<0.003
December-99	<0.003	<0.003	**0.030**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	**0.012**	<0.003	**0.169**	<0.003
March-00	<0.003	<0.003	**0.012**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	**0.017**	<0.003	**0.092**	<0.003
March-01	<0.003	<0.003	**0.017**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	**0.009 J**	<0.003
May-01	<0.003	<0.003	**0.026**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	**0.008 J**	<0.003	**0.012**	<0.003
March-02	**0.003 J**	<0.003	**0.003 J**	NS	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	**0.004 J**	**0.018**	<0.003
September-02	<0.003	<0.003	**0.048**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	**0.008 J**	--	--	<0.003
March-03	<0.003	<0.003	**0.037**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	**0.014**	<0.003
September-03	<0.003	<0.003	**0.009 J**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	**0.017**	<0.003
March-04	<0.003	<0.003	**0.008 J**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
September-04	<0.003	<0.003	**0.042**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
March-05	<0.003	<0.003	**0.026**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	**0.020**	<0.003	**0.012**	<0.003
September-05	<0.003	<0.003	**0.005 J**	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
March-06	<0.003	<0.003	<0.003	<0.003	<0.003	--	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	--	<0.003
September-06	<0.003	<0.003	**0.006 J**	<0.003	<0.003	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
March-07	<0.003	<0.003	**0.026**	<0.003	<0.003	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
September-07	<0.003	<0.003	<0.003	<0.003	<0.003	--	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
March-08	<0.003	<0.003	**0.029**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
September-08	<0.003	<0.003	**0.013**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
March-09	<0.003	<0.003	**0.022**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	**0.003 J**	--	--
September-09	<0.003	<0.003	**0.024**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
March-10	<0.003	<0.003	**0.016**	<0.003	<0.003	<0.003	--	**0.003 J**	<0.003	**0.003 J**	<0.003	<0.003	<0.003	--	--
September-10	<0.003	<0.003	**0.005 J**	<0.003	**0.003 J**	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
April-11	<0.003	<0.003	**0.010**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
November-11	<0.003	<0.003	**0.013**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
June-12	<0.003	<0.003	**0.018**	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--	--
November-12	<0.002	<0.002	**0.012**	<0.002	<0.002	<0.002	--	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	--
May-13	<0.002	<0.002	**0.018**	<0.002	<0.002	<0.002	--	<0.002	<0.002	**0.003 J**	<0.002	<0.002	<0.002	--	--
October-13	<0.002	<0.002	**0.037**	<0.002	<0.002	<0.002	--	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	--
April-14	<0.002	<0.002	**0.015**	<0.002	<0.002	<0.002	--	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	--
August-14	<0.002	<0.002	**0.010**	<0.002	<0.002	<0.002	--	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	--
March-15	<0.002	<0.002	**0.009 J**	<0.002	<0.002	<0.002	--	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	--
September-15	<0.002	<0.002	NS	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	--
March-16	**0.002 J**	<0.001	**0.052**	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002 J**	<0.001	<0.001	<0.001	**0.002 J**	--	--

GPS implemented

Notes:

Selenium concentrations are in milligrams per liter (mg/L)

GPS = Groundwater Protection Standard

NS = Not sampled due to insufficient water

Bold font = Detected concentration

= Concentration greater than GPS

underline =Concentration greater than current GPS; however, GPS was not in effect

APPENDIX A

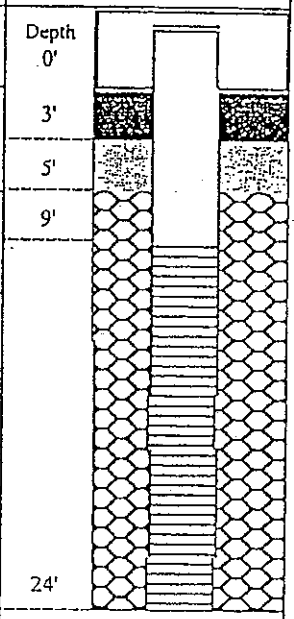
CECW-3 BORING LOG

BORING LOG

Identification:	CECW-3	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	25 August 98
Type: HSA	Total Depth: ~24'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	24'-9'

Depth (feet)	Sample No. (Depth ft)	Blow Counts	Recovery (inches)	Description of Material
0	0-2	2-2-3-2	16"	Tan, white medium to fine SAND
5	4-6	3-3-3-1	10"	Tan, white medium to fine SAND with lenses of orange medium sand
10	9-11	1-1 spoon fell	24"	Tan medium to fine SAND to dark gray silty clay, possible ash layer, moisture increasing
15	14-16	1- spoon fell	24"	Dark gray silty CLAY, possible ash layer, intersected water table
20	19-21	1- spoon fell	24"	Dark gray silty CLAY, possible ash layer, saturated
25				
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 18.40'.

WELL LEGEND

- PVC Riser
- PVC Screen
- Bentonite
- Cement Grout
- No. 2 Morie Sand

RESOURCE INTERNATIONAL, LTD.
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