

3R11-0820-09

**DRAFT SITE INSPECTION
FOR THE
BATTLEFIELD GOLF CLUB SITE
CITY OF CHESAPEAKE, VIRGINIA**

Prepared for

U.S. Environmental Protection Agency Region 3
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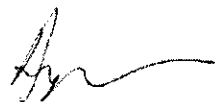
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1.0 INTRODUCTION

Under Eastern Area Superfund Technical Assessment and Response Team (START) Contract No. EP-S3-05-02, Technical Direction Document (TDD) No. E33-024-08-09-006, U.S. Environmental Protection Agency (EPA) Region 3 tasked Tetra Tech EM Inc. (Tetra Tech), to conduct a site inspection (SI) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) for the Battlefield Golf Club site located at 1001 South Centerville Turnpike, Chesapeake, Virginia. EPA's Compensation, and Liability Information System (CERCLIS) database identifies the site as the Battlefield Golf Club, EPA Identification No. VAN000306614 (Reference [Ref.] 1). In August 2008, Tetra Tech completed an EPA removal assessment at the site (under TDD No. E33-020-08-07-027). Sampling data obtained from this assessment has been incorporated into this SI.

This SI was conducted in accordance with EPA's "Guidance for Performing Preliminary Assessments Under CERCLA" and "Guidance for Performing Site Inspections Under CERCLA (Refs. 2 and 3). The purpose of this SI was to evaluate existing analytical data collected to determine the need for additional action under CERCLA. The scope of the SI for the Battlefield Golf Club site included a review of available information regarding the site, a compilation and evaluation of potential targets, evaluation of available analytical data, and the calculation of a preliminary Hazard Ranking System (HRS) score. The preliminary HRS score completed for this site is predecisional and, therefore, should not be released to the public. The preliminary HRS evaluation and calculation for this site has been submitted to EPA Region 3 as a separate, confidential document.

This report contains Section 1.0, the introduction, which presents the purpose of the SI and provides the organization of the report. This report summarizes site background information in Section 2.0; describes the source characteristics, and groundwater and surface water migration pathways in Sections 3.0, 4.0, and 5.0, respectively; discusses soil and air migration pathways in Section 6.0, and presents summaries and conclusions in Section 7.0. A list of references cited in the text is provided in Section 8.0. All figures are provided in Appendix A.

2.0 BACKGROUND

This section provides background information on the site, including its location, description, and history of site activities and investigations.

2.1 SITE LOCATION

The Battlefield Golf Club site is located at 1001 South Centerville Turnpike, Chesapeake, Virginia (see Figure 1, Site Location). The geographic coordinates of the approximate center of the site are 36.68982 degrees north latitude and 76.17790 degrees west longitude (Ref. 4). The site is surrounded by a mix of residential and agricultural properties, bordered to the north by Whittamore Road, to the south by Murray Drive, and to the west South Centerville Turnpike. Residential homes are located adjacent to the site to the west (along Centerville Pike South), to the south (along Murray Drive) and to the east and southeast (along Whittamore Road). The Naval Auxiliary Landing Field (NALF) Fentress (Fentress) is located directly west of the property. NALF Fentress comprises 2,560 acres with an additional 8,780 acres in restrictive easements (NALF Fentress) (Ref. 5).

2.2 SITE DESCRIPTION

The 216-acre property is the location of the currently active Battlefield Golf Club, which opened to the public on October 13, 2007. The golf course is described as a "links style" golf course, which is the oldest style of golf course first developed in Scotland. The term links refers to an area of coastal sand dunes in the Scots language (Refs. 6, 7 and 8). The course consists of 18 holes built around seven man-made lakes. The original elevation of the property has been altered to create elevations up to 40 feet above sea level (Ref. 6). In addition to the course, a trailer that functions as an office/club house and parking area are located on the site (Ref. 9). An aerial photograph appears as Figure 2 - 2005 Aerial Photograph. Prior to development as a golf course, the site was utilized for agricultural use, as it appears in Figure 3 - 1994 Aerial Photograph.

2.3 SITE BACKGROUND AND PREVIOUS SITE INVESTIGATIONS

In early 2001, Combustion Products Management (CPM) Virginia LLC approached the City of Chesapeake about the construction of a golf course on the site. A public meeting was held on

March 22, 2001 to invite comment and participation from nearby citizens, the City of Chesapeake, and local Virginia Department of Environmental Quality (VADEQ) representatives. A second public meeting was held on April 11, 2001. On June 20, 2001, the Chesapeake City Council voted unanimously to approve the golf course project (originally called the Etheridge Greens Golf Course) (Ref. 6).

The property purchased by CPM to be used for the golf course is located on Tax Map 62, Parcel 2. At the time of purchase by CPM, the property consisted of 215 acres of agricultural land and one acre of forested land. CPM purchased the property from Weaver Fertilizer Company, Inc. on March 15, 2002 (Ref. 11).

To alter the surface topography for the golf course, CPM used approximately 1.5 million cubic yards of coal combustion byproducts (CCB) from Dominion's Chesapeake Energy Center. A cementitious binder was added to the CCB at the power plant prior to hauling to the site (Ref. 6). The CCB consisted of fly ash commingled with small amounts of bottom ash. EPA's Toxicity Characteristic Leaching Procedure (TCLP) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver) analysis was completed for both the fly ash and bottom ash. TCLP test results indicated that the fly ash and bottom ash were not characterized as a hazardous waste due to toxicity characteristic under the Resource Conservation and Recovery Act (RCRA) regulations because the levels of the metals analyzed for by the TCLP did not exceed the RCRA standards used to characterize a waste as toxic or hazardous (Ref. 6).

As part of the initial investigations conducted prior to CPM's purchase of the property, Stokes Environmental Associates, Ltd. (Stokes) was retained to prepare a Phase I Environmental Site Assessment (ESA) of the property. The Phase I investigation was completed by Stokes in 2001. No recognized environmental conditions were documented during the Phase I (Ref. 12).

On February 1, 2001, McCallum Testing Laboratories (McCallum) advanced three hand auger borings at the site. The borings were installed to depths of 4.5 to 5.5 feet. Groundwater was encountered at between 2 to 2.5 feet below the ground surface (bgs). Soil horizons encountered were described as moist silty sand, moist sandy loam, followed by wet loamy sand and/or wet sand (Ref. 13). McCallum returned to the site in March 2001 to complete a subsurface exploration at the site. A total of 12 soil test borings were drilled to depths of 25.5 bgs. Temporary monitoring wells were installed at 4 of the 12 boring locations. Groundwater was

encountered at depths ranging from 2 to 6.5 feet bgs. The predominant soil encountered consisted of moist and wet sand or moist sandy clay (Ref. 14).

In November 2001, Stokes was retained by CPM to perform a Baseline Drinking Water Quality Survey in the vicinity of the site (Ref. 15). The objective of the survey was to document existing groundwater conditions and use in the vicinity of the site. The residential population located adjacent to the site relies on private drinking water wells for their potable supply. As part of the survey, 40 groundwater samples were collected from these nearby private drinking water wells at randomly selected properties located within 2,000 feet of the site. The samples were analyzed for the following inorganic substances: antimony; arsenic, barium, beryllium, cadmium, chromium, copper, cyanide, fluoride, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Antimony, barium, nickel, selenium, or cyanide was not detected in any of the 40 groundwater samples collected. Two of the 40 samples contained copper concentrations that were above EPA's maximum contaminant level (MCL) of 1,300 parts per billion (ppb) and one sample revealed levels of thallium that were above the MCL of 2.0 ppb. No other inorganic substance was detected above EPA's MCL (Ref. 15).

At completion of the CCB placement and compaction, a 12-inch earthen infiltration layer was placed directly above the CCB fill. This was initially to be followed by a 12-inch earthen erosion control layer capable of sustaining growth of indigenous plants and grasses. On January 31, 2007, CPM sold the property to MJ Global (Ref. 10). On March 3, 2007, MJ Global submitted a request to VADEQ to modify the thickness of the final cover from 24 inches to 18 inches (Refs. 6 and 10). The Virginia closure requirement regulating use of CCB, 9 VAC 20-85-120, "Regulation Governing Management of Coal Combustion By-Products", specifies a minimum of 18 inches of cover material, therefore, VADEQ approved the requested modification (Ref. 10).

In February and May 2007, inspections of the site were completed to support the requirements of the site's closure plan. Soil borings were dug at randomly selected locations throughout the site. Each of the borings revealed at least 18 inches of earthen material located throughout the site, as required by the closure plan (Ref. 16). The results of the closure investigations were submitted to VADEQ and the closure certificate for the site was issued by VADEQ on October 4, 2007. This certificate indicated that the requirements for closure of the site were met (Ref. 17).

In April, May and July 2008, a consultant retained by the City of Chesapeake collected samples of the CCB, off-site soil samples, on and off-site surface water and groundwater samples collected from on and off-site monitoring wells. Nearby residential well samples were also collected in April and July 2008.

The CCB samples were collected from eight hand auger borings installed throughout the site. In addition, three off-site, background soil samples were also collected from borings advanced during the installation of off-site monitoring wells MW-4 and MW-5. Soil samples were collected from the borings advanced during the installation of MW-4 and MW-5 at 8 to 9 feet bgs, 9 to 11 feet bgs and 29 to 31 feet bgs. The CCB and off-site soil samples were analyzed for total organic carbon, TCLP, synthetic precipitation leaching procedure (SPLP) and RCRA metals (Ref. 18). Figure 1 in Reference 18 is the sampling location map showing where the CCB and off-site samples were collected during this investigation. The analytical results of this investigation are discussed below in Section 3.0, Source Characteristics.

The groundwater samples collected during the City's investigation were collected from the three monitoring wells located on the site. In July 2008, two groundwater samples were collected from two off-site monitoring wells and one groundwater sample was collected off-site at the fire service facility located at the NALF Fentress. The samples were analyzed for most EPA target analyte list (TAL) metals (with the exception of calcium, potassium, and sodium), boron and molybdenum. The results of this investigation are discussed below in Section 4.0, Groundwater Migration Pathway.

The surface water samples were collected from the on-site ponded water and one off-site background sample was collected from an unnamed pond located off of Etheridge Manor Boulevard, approximately 1 mile southwest of the site. The surface water samples were analyzed for the same parameters as the groundwater samples. The analytical results of this investigation are discussed below in Section 5.0, Surface Water Migration Pathway.

In July 2008, Tetra Tech was tasked by EPA to complete a removal assessment at the Battlefield Golf Club site (Ref. 9). As part of the removal assessment, in August 2008 Tetra Tech advanced 13 borings to approximately 12 feet bgs along the perimeter of the site. Continuous sampling using 4-foot acetate sleeves allowed for documentation of soil lithology and sampling of soil cores at depth. Water was encountered in the borings between 4.5 and 7 feet bgs. Temporary

groundwater monitoring points were installed in the 13 borings. Tetra Tech collected one soil sample from each boring in the zone directly above the water table. Tetra Tech also collected groundwater samples from each of the 13 borings. The soil and groundwater samples were submitted under EPA's Contract Laboratory Program (CLP) for TAL metals (dissolved and total for the groundwater samples), boron and molybdenum analysis. In addition to the soil and groundwater samples, Tetra Tech also collected surface water samples from two locations along the unnamed surface water body that flows west to east along the southern boundary of the site. The surface water samples were also submitted through EPA's CLP for TAL metals, boron and molybdenum analysis. Finally, Tetra Tech collected groundwater samples from 55 residents located in the vicinity of the site. The residential well samples were also submitted for TAL metals, boron and molybdenum. Analytical results of this assessment are discussed in the following sections of this report.

3.0 SOURCE CHARACTERISTICS

3.1 SOURCE AREA

The source identified at this site is the 1.5 million cubic yards of CCB (fly ash) placed on the property during the construction of the golf course.

3.2 SAMPLING LOCATIONS

In April, May and July 2008, a consultant retained by the City of Chesapeake, collected samples of the fly ash that was placed on the site. The fly ash samples were collected from eight hand auger borings installed throughout the site. In addition, three off-site soil samples were also collected from borings advanced during the installation of off-site monitoring wells MW-4 and MW-5. Soil samples were collected from MW-4 and MW-5 borings at 8 to 9 feet bgs, 9 to 11 feet bgs and 29 to 31 feet bgs. The fly ash and off-site soil samples were analyzed for total organic carbon and TCLP, SPLP and RCRA metals (Ref. 18). Figure 1 in Reference 18, is the sampling location map showing where the fly ash and off-site soil samples were collected during this sampling event.

During the EPA removal assessment completed by Tetra Tech in 2008, soil samples were collected directly above the water table in 13 soil borings installed around the perimeter of the site. No fly ash was encountered during the installation of these borings; therefore, the soil

samples collected from the borings can be used to further establish background levels of metals for the area. Figure 4 in Appendix A shows the location of the soil borings installed by Tetra Tech during the removal assessment.

3.3 ANALYTICAL RESULTS

This SI was conducted in accordance with HRS protocol. In accordance with the HRS, the significance of the concentration of a compound detected in a sample is compared to the background concentration. A compound is considered significantly elevated if its concentration is at or above three times the concentration detected in the background sample. Background levels of metals in the vicinity of the Battlefield Golf Club site were obtained from a review of analytical data reported from the soil samples collected off-site in soil borings MW-4 and MW-5 and the perimeter of the golf course, outside the areas where fly ash was placed. The levels of arsenic, barium, beryllium, boron, mercury, molybdenum and selenium reported in fly ash samples collected on site were elevated at or above three times the highest level of these metals detected in non-fly ash containing background soil samples.

3.4 SOURCE CONCLUSIONS

The levels of arsenic, barium, beryllium, boron, mercury, molybdenum and selenium reported from analysis of fly ash samples collected at the source were three times the concentrations detected in non-source samples indicating that the fly ash contains these metals at levels higher than what would be naturally-occurring in soils located in the vicinity of the site.

4.0 GROUNDWATER MIGRATION PATHWAY

This section describes the site's geology, hydrogeologic setting, the targets associated with the groundwater migration pathway, and conclusions that can be made for the groundwater migration pathway.

4.1 GEOLOGIC SETTING

The site is located in the Coastal Plain physiographic province of Virginia. The Virginia Coastal Plain consists of a wedge of generally unconsolidated Jurassic and younger sediments increasing in thickness from nearly 0 feet in the east where the Coastal Plain borders the Piedmont physiographic province, to more than 6,000 feet beneath the northeastern part of the Eastern

Shore Peninsula. The sediments consist of Jurassic and Cretaceous clay, sand, and gravel overlain by a thin sequence of Tertiary marine sands, overlain by Quaternary sand, mud, and gravel. In Virginia, the Coastal Plain is dissected by the Chesapeake Bay, which was created approximately 5,000 to 6,000 years ago when the lower course of the Susquehanna River was flooded by rising sea level (Refs. 9, 12 and 15).

The site is directly underlain by Quaternary Columbia Group sediments. The sediments can generally be characterized as unconsolidated fining-upwards depositional sequences of gravel, sand, silt, and clay. The sediments were deposited in fluvial-deltaic and estuarine settings similar to those that exist in the modern Chesapeake Bay and its tidal tributaries (Refs. 9, 12, and 15).

4.2 HYDROGEOLOGIC SETTING

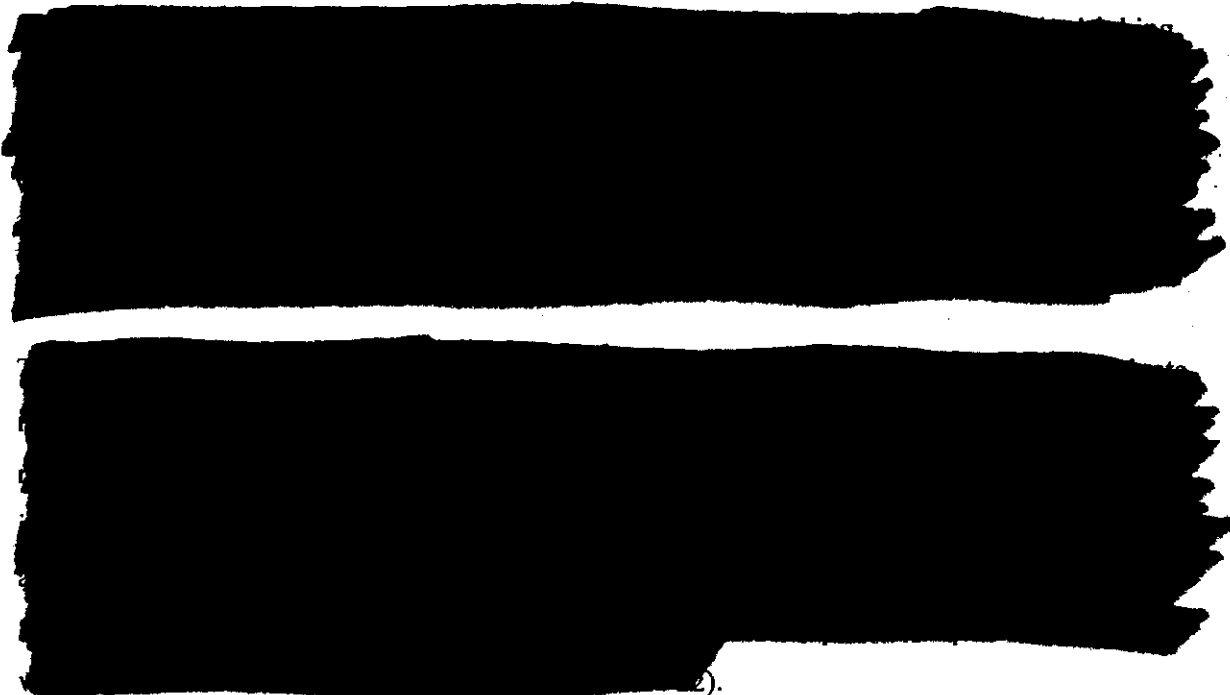
Sediments of the Coastal Plain physiographic province are classified into a series of 19 hydrogeologic units designated as aquifers or confining zones. The uppermost aquifer is the unconfined surficial aquifer (also called the Columbia aquifer), which is composed of unconsolidated interbedded gravel, sand, silt, and clay. The surficial aquifer is utilized for private domestic wells. The aquifer is principally recharged by precipitation infiltration. Because of the stratified nature of the sediments, horizontal hydraulic conductivity is generally greater than vertical hydraulic conductivity, and most of the unconfined groundwater flows relatively short distances before discharging to nearby streams and water bodies. A small amount, however, reaches deeper, confined aquifers. The Columbia aquifer is underlain by the Yorktown confining zone. The Yorktown confining zone consists of finer-grained sediment and is reported to be approximately 25 feet thick in the vicinity of the site. The Yorktown confining zone is underlain by the Yorktown-Eastover aquifer, which is composed of thick to massively bedded shelly sand and lesser clay intervals. The recharge to this aquifer is primarily through downward leakage of water from the overlying Columbia aquifer (Refs. 9, 12, and 15).

Commercial well logs approximately 2.5 miles northwest of the site described by Meng and Harsh indicate that the surficial aquifer near the site extends from ground surface to 70 feet below ground surface (bgs). According to the well logs, the Yorktown confining zone is approximately 25 feet thick (from 70 to 95 feet bgs). The Yorktown-Eastover aquifer is documented to begin at 95 feet bgs and continue to a depth of 358 feet bgs. Available well logs

reviewed for some of the private domestic wells located in the vicinity of the site indicate well depths ranging from 32 to 105 feet bgs, with screened intervals ranging from 37 - 42 feet bgs to 110 - 123 feet bgs (Ref. 15).

During the field activities completed as part of Tetra Tech's assessment of the Battlefield Golf Fly Ash Assessment site, the Columbia aquifer was gauged between 3 and 8 feet bgs, approximately 15 feet above mean sea level (AMSL). Based on groundwater gauging data and an elevation survey of temporary monitoring points completed during the assessment, groundwater was determined to flow southeast. A map showing the estimated groundwater flow direction is included as Figure 5, Groundwater Elevation Map, in Appendix A. Tetra Tech's determination that groundwater flows to the southeast confirms an earlier groundwater flow determination based on the groundwater elevations recorded for the on-site monitoring wells in 2008. This groundwater gradient map also showed groundwater flow to the southeast (see figure 2 in Reference 18).

4.3 GROUNDWATER TARGETS



The population located within each distance category assessed with the HRS that currently rely on wells for their potable supply are summarized below in Table 1. Figure 6 in Appendix A

provides the 4-mile target distance limit map for the site showing the location of the public supply wells and the area currently relying on private domestic wells (Refs. 19 and 25).

**TABLE 1
DRINKING WATER WELLS WITHIN 4 MILES OF SITE**

| Radial Distance from Site (miles) | Number of Residential Wells | Population Served by Residential Wells* | Number of Public Supply Wells | Population Served by Public Supply Wells | Total Population Served by Groundwater Sources |
|--|------------------------------------|--|--------------------------------------|---|---|
| 0.00 to 0.25 | 52 | 145 | 0 | 0 | 145 |
| 0.25 to 0.50 | 14 | 39 | 0 | 0 | 39 |
| 0.50 to 1.0 | 22 | 61 | 0 | 0 | 61 |
| 1.0 to 2.0 | 20 | 17 | 0 | 0 | 17 |
| 2.0 to 3.0 | 21 | 56 | 1 | 50 | 106 |
| 3.0 to 4.0 | 115 | 321 | 2 | 75 | 396 |
| TOTAL | 244 | 639 | 3 | 125 | 764 |

Notes: * = Based on average population per household for Chesapeake County, VA of 2.79 persons.

4.4 SAMPLE LOCATIONS AND ANALYTICAL RESULTS

This section describes the groundwater sample locations and analytical results obtained from on and off-site monitoring wells and nearby residential wells.

4.4.1 MONITORING WELL SAMPLE RESULTS

In May, July and August 2008, consultants for the City of Chesapeake collected groundwater samples from the three monitoring wells located on site. Two groundwater samples were also collected from two off-site monitoring wells (MW-4 and MW-5) and one groundwater sample was collected off-site at the fire service facility located at the NALF Fentress. All of the samples were analyzed for most TAL metals (with the exception of calcium, potassium, and sodium), boron and molybdenum. The levels of inorganic compounds detected in off-site monitoring well MW-4 were compared to the levels reported in the on-site samples. MW-4 was used for comparison because it was screened at similar depth bgs as the on-site wells. The levels of arsenic, barium, chromium, copper, iron, lead, mercury, vanadium and zinc reported in the on-site wells during this investigation were at or above three times the levels reported in MW-4. The levels of arsenic and lead were also reported above the EPA MCL of 15 parts per billion (ppb) (Ref. 18).

As part of the EPA removal assessment completed by Tetra Tech, 13 temporary groundwater monitoring points were installed around the perimeter of the site as shown in Appendix A, Figure 4. Tetra Tech collected groundwater samples from each of the 13 monitoring points as well as the three existing on-site monitoring wells. The groundwater samples were submitted under EPA's CLP for TAL metals (dissolved and total), boron and molybdenum analysis. The levels of arsenic, chromium and lead were reported at three times the levels detected in the off-site background well (MW-4). The levels of arsenic and lead were also reported above the corresponding EPA MCL of 10 ppb for arsenic and 15 ppb for lead (there is no MCL established for chromium) (Ref. 9). The on-site groundwater sample results that were elevated three times above background and exceeding the corresponding EPA MCLs are summarized in Table 2.

**TABLE 2
ON-SITE GROUNDWATER SAMPLES
ANALYTICAL RESULTS EXCEEDING EPA MCLs**

| Metal | Sample Identifier | Sample Date | Concentration (ppb) | Background Concentration (MW-4) | MCL (ppb) |
|--------------|--------------------------|--------------------|----------------------------|--|------------------|
| Arsenic | MW-1 | 05/20/08 | 64.6 | ND | 10.0 |
| | MW-1 | 07/14/08 | 72.7 | | |
| | MW-2 | 05/20/08 | 79.8 | | |
| | MW-2 | 07/14/08 | 21.0 | | |
| | MW-3 | 05/20/08 | 103 | | |
| | MW-3 | 07/14/08 | 71.3 | | |
| | BG08-GW-MP02 | 8/29/08 | 10.7 | | |
| | BG08-GW-MP07 | 8/28/08 | 19.8 | | |
| | BG08-GW-MP09 | 8/29/09 | 13.2 | | |
| Lead | MW-1 | 05/20/08 | 67.9 | ND | 15.0 |
| | MW-1 | 07/14/08 | 26.3 | | |
| | MW-2 | 05/20/08 | 78.7 | | |
| | MW-2 | 07/14/08 | 15.3 | | |
| | MW-3 | 05/20/08 | 106 | | |
| | MW-3 | 07/14/08 | 66.8 | | |
| | BG08-GW-MP06 | 08/28/09 | 17.3 | | |
| | BG08-GW-MP07 | 08/28/09 | 28.3 | | |
| | BG08-GW-MP08 | 08/29/09 | 20.9 | | |
| | BG08-GW-MP09 | 08/29/09 | 27.3 | | |
| | BG08-GW-MP10 | 08/29/09 | 20.4 | | |
| | BG08-GW-MW02 | 08/29/09 | 15.6 | | |
| | BG08-GW-MW03 | 08/29/09 | 16.2 | | |

Notes: MCL = Maximum contaminant level
 ND = Not detected above the contract required quantitation limit
 Ppb = parts per billion

4.4.2 RESIDENTIAL WELL SAMPLE RESULTS

Groundwater samples from residential wells located in the vicinity of the site have been collected in 2001, prior to placement of the fly ash on the property and during three sampling events completed in 2008. In November 2001, Stokes was retained by CPM to perform a Baseline Drinking Water Quality Survey in the vicinity of the site (Ref. 15). The objective of the survey was to document existing groundwater conditions and use in the vicinity of the site. As part of the survey, 40 groundwater samples were collected from private drinking water wells randomly selected within 2,000 feet of the site. Residents along Murray Drive, Whittamore Road, Centerville Turnpike, and Land of Promise Road were sampled. The samples were analyzed for antimony, arsenic, barium, beryllium, cadmium, chromium, copper, cyanide, fluoride, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Antimony, barium, nickel, selenium, or cyanide was not detected in any of the 40 groundwater samples collected. Two of the 40 samples contained copper concentrations that were above EPA's MCL of 1,300 ppb and one sample revealed levels of thallium that were above the corresponding MCL of 2.0 ppb. No other inorganic substance was detected above EPA's MCL (Ref. 15).

In April and July 2008, the City of Chesapeake collected groundwater samples from residences located in the vicinity of the site (53 homes were sampled in April and 23 homes were sampled in July). Lead was detected above EPA's MCL of 15 ppb in three wells sampled (at 56 ppb, 27 ppb and 31 ppb). No other metals were reported above the corresponding EPA MCL (Ref. 23).

Between August 2 and 29, 2008, Tetra Tech and EPA collected groundwater samples from 55 residents located in the vicinity of the site. The samples were analyzed for EPA TAL metals, molybdenum and boron. Lead was reported above the EPA MCL in groundwater collected from four residents (detected at 67.1 ppb, 18.6 ppb, 17.9 ppb and 18.9 ppb). No other compound was detected above the corresponding EPA MCL (Ref. 9).

The exact locations where the residential well samples were collected is confidential information and therefore not included in this report.

The results of the 2001 and 2008 residential well sampling events were reviewed to determine if evidence of a release into groundwater from the fly ash placed on to the site could be established. The protocol used under the HRS to establish an observed release is documentation that concentrations of contaminants of concern (detected in uncontained on-site sources) were

reported at three times the concentrations reported in background samples. As documented by the analytical results of samples collected of the fly ash, the contaminants of concern associated with this site are arsenic, barium, beryllium, boron, mercury, molybdenum and selenium. In addition, chromium, copper, iron, lead, vanadium and zinc were detected in on-site groundwater samples three times above the level reported in samples collected upgradient to the site; therefore, to conservatively evaluate the site these compounds have been included for evaluation in residential wells. Based on groundwater gradient maps generated for the site, groundwater is expected to flow to the southeast; therefore, wells sampled along Blue Ridge Drive represent background conditions. In addition, groundwater samples collected in 2001 can also be used to establish background groundwater conditions because the samples were collected prior to placement of fly ash on the site.

Table 3 summarizes the background metals concentrations established from the results of groundwater samples collected downgradient of the site in 2001 (along Murray Drive south of the site and Whittamore Road east/southeast of the site) and in groundwater samples collected in 2008 from residents located along Blue Ridge Drive.

**TABLE 3
2001 RESIDENTIAL WELL SAMPLES
ANALYTICAL RESULTS
BACKGROUND SAMPLES**

| Compound of Concern | Background Concentration* (ppb) | 3X Background Concentration (ppb) | Sample Date |
|----------------------------|--|--|--------------------|
| Arsenic | ND | ND | 11/2001 |
| | 1.6 | 4.8 | 8/2008 |
| Barium | ND | ND | 11/2001 |
| | 84.1 | 252.3 | 8/2008 |
| Beryllium | ND | ND | 11/2001 |
| | ND | ND | 8/2008 |
| Boron | NA | NA | 11/2001 |
| | 137 | 411 | 8/2008 |
| Chromium | 8 | 24 | 11/2001 |
| | 0.9 | 2.7 | 8/2008 |
| Copper | 1,623 | 4,869 | 11/2001 |
| | 441 | 1,323 | 8/2008 |
| Lead | 10 | 30 | 11/2001 |
| | 8.4 | 25.2 | 8/2008 |

**TABLE 3
2001 RESIDENTIAL WELL SAMPLES
ANALYTICAL RESULTS
BACKGROUND SAMPLES (continued)**

| Compound of Concern | Background Concentration* (ppb) | 3X Background Concentration (ppb) | Sample Date |
|---------------------|---------------------------------|-----------------------------------|-------------|
| Iron | 5,670 | 17,010 | 11/2001 |
| | 5,740 | 17,220 | 8/2008 |
| Mercury | 0.7 | 2.1 | 11/2001 |
| | ND | ND | 8/2008 |
| Molybdenum | NA | NA | 11/2001 |
| | ND | ND | 8/2008 |
| Selenium | ND | ND | 11/2001 |
| | ND | ND | 8/2008 |
| Vanadium | NA | NA | 11/2001 |
| | ND | ND | 11/2001 |
| Zinc | 40 | 120 | 8/2008 |
| | 140 | 420 | 11/2001 |

Notes: * = Highest concentration reported in background samples is used.
 NA = Not analyzed for
 ND = Not detected above the laboratory contract required quantitation limit
 Ppb = parts per billion

Table 4 below summarizes the downgradient residential well analytical results.

**TABLE 4
RESIDENTIAL WELL SAMPLES ANALYTICAL RESULTS
DOWNGRAIDENT SAMPLES**

| Compound of Concern | MCL | 3X Background Concentration (ppb) | Highest Downgradient Concentration Reported (ppb) | Number of Wells with Concentrations 3X Background* |
|---------------------|-------|-----------------------------------|---|--|
| Arsenic | 10 | 4.8 | 2.6 | 0 |
| Barium | 2,000 | 252.3 | 192 | 0 |
| Beryllium | 4 | ND | ND | 0 |
| Boron | NS | 411 | 905 | 3 |
| Chromium | 2 | 24 | 1.9 | 0 |
| Copper | 1,300 | 4,869 | 488 | 0 |
| Iron | NS | 17,220 | 17,300 | 1 |
| Lead | 15 | 30 | 67.1 | 4 |
| Mercury | 2 | 2.1 | ND | 0 |
| Molybdenum | NS | ND | ND | 0 |
| Selenium | 50 | ND | ND | 0 |
| Vanadium | NS | ND | ND | 0 |
| Zinc | NS | 420 | 3,090 | 2 |

Notes: MCL = Maximum contaminant level
 NS = MCL not established for this compound
 ND = Not detected above the contract required quantitation limit ...
 ppb = parts per billion

4.5 GROUNDWATER CONCLUSIONS

The source identified at this site is the 1.5 million cubic yards of fly ash placed on the property during the construction of the golf course. Analytical results from samples collected of this material indicate levels of arsenic, barium, beryllium, boron, mercury, molybdenum and selenium at or above three times the highest level detected in background soil samples. In addition, groundwater samples collected from on-site monitoring points and monitoring wells revealed arsenic, barium, chromium, copper, iron, lead, mercury, vanadium and zinc in some on-site monitoring points at or above three times the level detected in groundwater collected from an off-site background well indicating that the fly ash placed on the site may be impacting shallow groundwater underlying the site.

It cannot be concluded from the available data that the fly ash placed on the site has impacted nearby residential wells. As shown in Table 4 above, of the 55 wells sampled by EPA only eight wells had reported concentrations for certain metals that were three times above the background concentrations. The compounds of concern are naturally occurring in groundwater and may be due to other sources, such as lead-containing solder in the home's plumbing system. Although, a release to nearby residential wells is not satisfactorily established with existing data, future data may indicate that the fly ash placed at the site has migrated off site and impacted nearby residential wells.

5.0 SURFACE WATER MIGRATION PATHWAY

This section describes the site's hydrologic setting, targets associated with the surface water migration pathway, and conclusions made for the surface water migration pathway.

5.1 HYDROLOGIC SETTING

Surface water drainage from the site flows either into the on-site ponds or to the south and enters a drainage ditch located along the southern border of the site. The drainage ditch flows to the southeast and then north, eventually discharging into Pocaty River. The Pocaty River flows east approximately 7.1 miles until discharging into the North Landing River. The 15-mile HRS downstream target distance limit (TDL) is completed within North Landing River. The 15-mile TDL is shown on Figure 7 in Appendix A.

5.2 SURFACE WATER TARGETS

There are no surface water intakes located along the 15-mile TDL (Ref. 19). The Pocaty and North Landing River are utilized for recreational uses including fishing and boating (Ref. 24). Sensitive environments located along the TDL include approximately 23 miles of wetland frontage and habitat known or likely to be used by the state and federally-listed threatened or endangered species summarized in Table 5 (Ref.25).

**TABLE 5
STATE AND FEDERAL ENDANGERED AND THREATENED SPECIES**

| Species Scientific Name | Species Common Name | Status |
|--|--------------------------------------|--------------------------|
| <i>Picoides borealis</i> | Woodpecker, red-cockaded | Federal/State Endangered |
| <i>Caretta caretta</i> | Turtle, loggerhead sea | Federal/State Threatened |
| <i>Corynorhinus rafinesquii macrotis</i> | Bat, Rafinesque's eastern, big-eared | State Endangered |
| <i>Crotalus horridus</i> | Rattlesnake, canebrake | State Endangered |
| <i>Falco peregrinus</i> | Falcon, peregrine | State Threatened |
| <i>Bartramia longicauda</i> | Sandpiper, upland | State Threatened |
| <i>Haliaeetus leucocephalus</i> | Eagle, bald | Federal/State Threatened |
| <i>Sorex longirostris fisheri</i> | Shrew, Dismal swamp southeastern | State Threatened |
| <i>Lanius ludovicianus migrans</i> | Shirke, migrant loggerhead | State Threatened |

5.3 SAMPLING LOCATIONS AND ANALYTICAL RESULTS

In April, May and July 2008, a consultant to the City of Chesapeake collected surface water samples from the on-site ponded water and one off-site background sample from an unnamed pond located off of Etheridge Manor Boulevard, approximately 1 mile southwest of the site. The sampling locations are shown in Reference 18, Figure 1. The surface water samples were analyzed for most EPA TAL metals (with the exception of calcium, potassium, and sodium), boron and molybdenum. As shown in Appendix A, Figure 4, two surface water samples were also collected by Tetra Tech during the 2008 removal assessment from the drainage ditch located south of the site.

To determine the significance of the levels of compounds of concern detected in the on-site surface water samples, the reported concentrations were compared to the concentrations detected in the background sample. As shown in Table 6, the levels of aluminum, arsenic, cobalt and iron reported in the on-site surface water samples were at least three times higher than the level reported in the off-site, background surface water sample.

TABLE 6
SURFACE WATER SAMPLES ANALYTICAL RESULTS
BACKGROUND SAMPLES

| Compound of Concern | Background Concentration (ppb) | 3X Background Concentration (ppb) | Surface Water Samples Concentration* |
|----------------------------|---------------------------------------|--|---|
| Arsenic | 634 | 1,902 | 25,100 |
| Barium | 38.4 | 115.2 | 130.0 |
| Beryllium | 0.10 | ND | ND |
| Boron | 36.1 | 108.3 | 59.6 |
| Chromium | ND | ND | 37.1 |
| Lead | ND | ND | 7.0 |
| Mercury | ND | ND | ND |
| Molybdenum | ND | ND | ND |
| Selenium | ND | ND | ND |

Notes: * = Surface water samples collected from drainage ditch
 ND = Not detected above the contract required quantitation limit
 ppb = parts per billion

5.4 SURFACE WATER CONCLUSIONS

The analytical results for surface water samples collected from on-site ponds indicate aluminum, arsenic, barium, chromium, and lead concentrations are three times the level detected in one surface water sample collected upstream. Because the compounds of concern associated with this site are naturally occurring, analysis of additional background surface water samples are necessary to determine if the elevated concentrations are due to fly ash.

6.0 SOIL EXPOSURE AND AIR MIGRATION PATHWAYS

This section provides information regarding targets associated with the soil exposure and air migration pathways. The analytical results for soil samples collected at the site were discussed in Section 3.3.

6.1 PHYSICAL CONDITIONS

Soil horizons encountered during subsurface explorations completed on the site were described as moist silty sand, moist sandy loam, followed by wet loamy sand and wet sand. The water table was encountered at depths ranging from 2 to 6.5 feet bgs (Refs. 9 and 13). The VADEQ closure requirement regulating use of fly ash specifies a minimum of 18 inches of cover material; however, during Tetra Tech's site investigation in 2008, fly ash was observed at approximately 4 inches bgs at the top of higher elevated mounded areas.

6.2 SOIL AND AIR TARGETS

The site is currently used as an active golf course with no restrictions to access. The population residing within a 4-mile radius of the site is summarized below in Table 7 (Ref. 26). In addition to the human population, other targets identified to the soil and air migration pathways within a 4-mile radius of the site include approximately 8,950 acres of wetlands as shown in Table 8 (Ref. 3).

**TABLE 7
POPULATION WITHIN 4 MILES OF SITE**

| Radial Distance from Site (miles) | Population (number of persons) |
|--|---|
| 0.00 - 0.25 | 92 |
| 0.25 - 0.50 | 122 |
| 0.50 - 1.0 | 623 |
| 1.0 - 2.0 | 11,499 |
| 2.0 - 3.0 | 6,174 |
| 3.0 - 4.0 | 9,929 |

**TABLE 8
WETLAND ACREAGE WITHIN 4 MILES OF SITE**

| Radial Distance from Site (miles) | Wetlands (acreage) |
|--|-------------------------------|
| 0.00 - 0.25 | 0 |
| 0.25 - 0.50 | 49.98 |
| 0.50 - 1.0 | 105.71 |
| 1.0 - 2.0 | 989.88 |
| 2.0 - 3.0 | 3,319.27 |
| 3.0 - 4.0 | 4,485.04 |

7.0 SUMMARY AND CONCLUSIONS

The Battlefield Golf Club site consists of 1.5 million cubic yards of fly ash placed on a 216-acre property to alter the surface topography during construction of a golf course. A cementitious binder was reportedly added to the fly ash prior to hauling to the site. The metals associated with the fly ash have been identified through the analytical results of samples collected of the fly ash. These laboratory results indicated elevated levels of arsenic, barium, beryllium, boron, mercury, molybdenum and selenium when compared to the concentrations of these metals in background soil samples.

Groundwater samples collected from on-site monitoring wells and temporary monitoring points indicated the presence of elevated levels of arsenic, barium, chromium, copper, iron, lead, mercury, vanadium and zinc at concentrations exceeding a background groundwater sample. Groundwater samples collected from nearby residential wells indicated elevated levels of boron, iron, lead and/or zinc in eight of the 55 residential wells sampled. The analytical results for surface water samples collected from on-site ponds indicated aluminum, chromium, and lead concentrations three times the background level.

The compounds associated with this site are naturally-occurring metals. Some of the metals detected in on-site groundwater and surface water samples that exceeded the background concentrations were not detected in samples collected of the fly ash on the site; therefore, their presence in groundwater and surface water cannot be attributed with the existing laboratory data to the fly ash. Because the metals associated with this site are naturally occurring to definitively attribute elevated concentrations detected in on-site groundwater and surface water samples, additional samples of the fly ash should be collected and analyzed for EPA's TAL metals.

The groundwater migration pathway is the pathway of concern associated with this site. Although the current data does not provide evidence that the fly ash has impacted nearby residential wells due to the amount of fly ash placed on the site, the documented high water table and relatively shallow residential wells, future migration of metals contained in the fly ash remains a potential risk to nearby residential wells.

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