# COKE POINT AREA GROUNDWATER CORRECTIVE MEASURES STUDY WORK PLAN

TRADEPOINT ATLANTIC
SPARROWS POINT, MARYLAND

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ARM Project No. 20010302

Revision 1 – January 14, 2021

# TABLE OF CONTENTS



## FIGURES

## APPENDICES

# 1.0 INTRODUCTION

The Coke Point Area (CPA) (the Site) is located in the southwestern portion of the Tradepoint Atlantic (TPA) Property and comprises Parcels B10, B11 and B12, as the entire property has been divided into several separate parcels. The CPA includes the Coke Oven Area or COA (Parcel B10), which has been the subject of ongoing interim measures to address groundwater, and the Coke Point Landfill (Parcel B12), which is a closed landfill that receives semi-annual groundwater monitoring. A Dredged Material Containment Facility (DMCF) is also located in the CPA.

Data gaps with respect to groundwater in the COA have been noted in the findings and recommendations of the Coke Oven Interim Measures 2018 Progress Report, Revision 0, dated February 2019, and the United States Environmental Protection Agency (EPA) letter, dated December 3, 2018, submitted in response to the report Assessment of Current Groundwater to Surface Water Discharges from the Coke Point Area (ARM, 2018). The EPA also provided comments on the existing interim measures in a March 20, 2019 letter on the Former COA IM Supplemental Investigation Work Plan.

As a result, the "Former Coke Oven Area Interim Measures Supplemental Investigation Report" (Rev 0 dated August 2, 2019) was completed to improve the understanding of groundwater conditions in the COA, to address the concerns raised by the Maryland Department of the Environment (MDE) and EPA outlined in the comments mentioned above, and to support an evaluation of the most relevant and effective additional corrective actions for the groundwater conditions at the COA. In addition to the supplemental onshore investigation activities, pore water and surface water samples were collected from locations in the areas just offshore of the COA to assess the current risk to offshore aquatic receptors.

Based on the results of the supplemental investigations, it was concluded that the remaining groundwater impacts do not present an imminent endangerment to human health or the environment that would necessitate additional interim measures prior to completion of a Corrective Measures Study (CMS) to determine an appropriate final remedy for the groundwater impacts at the Site. Since the "coke point" peninsula represents a distinct groundwater unit, it was recommended that the proposed CMS address the CPA as a whole. The investigation report recommended that a CMS be initiated.

# 2.0 CURRENT CONDITIONS

## 2.1 Site Setting and Use

The TPA Property is located in Baltimore County, Maryland within the southeastern corner of the Baltimore metropolitan area, and approximately nine miles from downtown. The property encompasses approximately 3,100 acres of land located on a peninsula situated on the Patapsco River near its confluence with the Chesapeake Bay, and physically positioned in the mouth of the heavily industrialized and urbanized Baltimore Harbor / Patapsco River region. **Figure 1** shows the location and boundaries of the Tradepoint Atlantic property.

From the late 1800s until 2012, the property was used for the production and manufacturing of steel. Iron and steel production operations and processes at the TPA Property included raw material handling, coke production, sinter production, iron production, steel production, and semi-finished and finished product preparation. In 1970, Sparrows Point was the largest steel facility in the United States, producing hot and cold rolled sheets, coated materials, pipes, plates, and rod and wire. The steelmaking operations at the facility ceased in fall 2012, and the steel mill has been demolished. Current plans for the TPA Property include redevelopment over the next several years. Some portions of the TPA Property have already undergone remediation and/or redevelopment.

The CPA (the Site) is located in the southwestern portion of the TPA Property, and is the location of the former coking operations from the 1940's to the early 1980's. **Figure 2** shows the location and boundaries of the CPA. The Coke Point Landfill occupies approximately 41 acres in the southwest corner of the CPA and received a variety of non-hazardous waste. The DMCF is a 24-acre area located north of the landfill that was constructed to hold material from maintenance dredging operations.

The Parcel is currently zoned Manufacturing Heavy-Industrial Major (MH-IM) and current uses on the Site include recovery of scrap metal, reclamation and processing of slag, and stockpiling and handling of bulk commodity materials. There is currently no groundwater use within the CPA.

## 2.2 Interim Measures

A number of interim measures (IMs) have been implemented to address groundwater impacts in the CPA. **Figure 3** shows the locations of the existing interim measures within the CPA. The IMs currently in operation at the COA are located within five distinct smaller areas designated as Cells 1-3, 5, and 6. Below is a list of the cells, the name of the area they cover, and their current IM system(s):

- Cell 1 (former Benzol Processing Area): Air Sparge/Soil Vapor Extraction (AS/SVE) system;
- Cell 2 (former Coal Basin Area): AS/SVE system in the shallow groundwater zone and groundwater pump and treat (GW P&T) system in the intermediate zone;
- Cell 3 (Cove Area): AS/SVE system;
- Cell 5: Dense Non-Aqueous Phase Liquid (DNAPL) Recovery system and Dual Phase Extraction (DPE) system for the shallow zone; and
- Cell 6 (former Benzol Processing Area): Multi-Phase Extraction (MPE) of Light Non-Aqueous Phase Liquid (LNAPL).

Cell 1 is located in the former Coal Basin area. Cell 1 consists of an AS/SVE system that is coupled with a vapor-phase granular activated carbon (VGAC) off-gas treatment unit. The purpose of the AS/SVE system is to remove volatile organic compounds from the subsurface, while the purpose of the VGAC off-gas treatment unit is to capture VOCs that are present within extracted vapors. The findings in the CO IM 2018 Progress Report (ARM, 2019) indicated the AS/SVE system is continuing to remove volatile hydrocarbons from the subsurface in the Cell 1 area and that the concentrations of total VOCs in groundwater at the two monitoring wells located within or downgradient of the Cell 1 boundary exhibit overall downward trends in concentration since the restart of system operation on April 5, 2017. Based on this information, the progress report recommends that the existing system should continue to be operated and monitored in accordance with current practices, although consideration will be given to operating the system on an intermittent basis (i.e., periodic shut downs of optimal length to be determined) during parts of 2019 in an attempt to maximize hydrocarbon removal amounts and efficiencies. Continued use of this system should be evaluated subsequent to 2019 depending on long-term groundwater quality requirements to be defined for the CO in 2019.

Cell 2 is located in the former Benzol Processing area. Cell 2 includes an AS/SVE system for the shallow groundwater zone and a GWPT system for the intermediate groundwater zone in the former Coal Basin Area of the site. The primary focus of the IMs for this area is the presence of elevated concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) and naphthalene in the intermediate groundwater zone. The findings in the CO IM 2018 Progress Report (ARM, 2019) indicated the existing GWPT system appeared to be effectively removing hydrocarbons from the subsurface and should continue to be operated and monitored in accordance with current practices. The AS/SVE system was not providing effective removal (i.e., less than 0.1 pounds of hydrocarbons removed in 2018) and was shut down in April 2018 as a result.

Cell 3 is located south of the former Benzol Processing area and north of a cove on the western shore of the COA. No specific historical plant operations have been identified in this area. The Cell 3 IM consists of an AS/SVE system for the shallow groundwater zone. The primary focus of the IM for this area is the presence of elevated concentrations of BTEX and naphthalene in the shallow groundwater zone (between approximately 20 and 27 feet below grade, near the base of the fill materials located above the native underlying clay and silt layers). The findings in the CO IM 2018 Progress Report (ARM, 2019) indicated that the existing AS/SVE system was not effectively removing significant hydrocarbon mass. It was recommended that consideration be given to modifying the system or utilizing alternate approaches. As a result of vertical profiling completed in the supplemental investigation, modifications to address a deeper groundwater zone have been proposed for the AS/SVE system.

Cell 5 is located in the former Coal Tar Storage area, just west of the Turning Basin. Cell 5 includes a DPE system and a DNAPL recovery system for the shallow groundwater zone on the Turning Basin side of the former COA. The primary focus of the IMs for this area is naphthalene in the shallow groundwater zone. The findings in the CO IM 2018 Progress Report (ARM, 2019) indicated that the DPE system was not effectively removing hydrocarbons. It was recommended that consideration be given to modifying the current system. The DNAPL system seemed to be operating effectively and should continue to be operated and monitored in accordance with current practices.

Cell 6 consists of an LNAPL Multi-Phase Extraction (MPE) monitoring and recovery system at the Former Benzol Processing Area, along with some manual bailing and skimming. The extraction system and manual bailing removed an estimated 11,000 pounds of LNAPL during 2018, with a cumulative removal amount of approximately 146,882 pounds since LNAPL recovery was initiated in Cell 6 in July 2010 (the MPE system began operation in October 2016). The findings in the CO IM 2018 Progress Report (ARM, 2019) indicated that while the MPE system is continuing to remove LNAPL from the subsurface with reasonable efficiency, potential upgrades to the system will be evaluated in 2019.

### 2.3 Nature and Extent of Contamination

The nature and extent of contamination has been delineated in previous investigations and periodic groundwater monitoring within the COA (Parcel B10) and around the Coke Point Landfill in Parcel B12. The EPA commented in their October 8, 2019 comments that the DRO/GRO contamination has not been defined, based on new criteria for DRO and GRO in the aquatic environment. However, the historic presence of DRO/GRO in the form of NAPL, in the area offshore of the CPA has been documented in previous offshore investigations.

Within the COA the extent of contamination is defined by plumes of two primary constituents of concern (COCs) – benzene and naphthalene. The sources of these COC plumes are identified zones of NAPLs in Cell 6 and Cell 5. The limits of these NAPL source areas have been defined in the "Pre-Design Investigation Report for the Former Coke Oven Area" (Key, 2015). In its comments, EPA noted that the naphthalene concentration in well COR-MWI is higher than in surrounding wells, and that the source of this naphthalene impact has not been characterized. It should be noted that this area was offshore until at least 1957. The well is completed at the base of the slag fill and NAPL has been identified in the well, so it is likely that this is NAPL from historical direct discharges that has subsequently been covered by fill.

The lateral extent of the COC plumes in both the shallow and intermediate zones in the COA was defined in the "Coke Oven Area Interim Measure Supplemental Investigation Report" (Revision 0 dated 8/2/2019). In the western portion of the COA, the plume migrates radially to the north, south and west from the Cell 6 NAPL area. Groundwater impacts extend to the Patapsco River shoreline, although concentrations along the west shore of the COA are generally low relative to concentrations to the northwest and to the southwest. To the north, the shallow plume is confined by the concrete seawall, but the intermediate zone plume extends under the Coal Basin to the graving dock dewatering system. In the eastern portion of the COA, the plume originates in the Cell 5 DNAPL area and is limited to the shallow zone. The plume extends east to the shoreline of the industrial Turning Basin and the extent has been defined to the north by unimpacted monitoring wells.

A separate isolated plume of benzene is present in the shallow groundwater in the eastern portion of the Coke Point Landfill area. This plume is centered on well CP08-PZM008 approximately 1,200 feet from the closest shoreline, and is delineated by much less impacted monitoring wells and determined to be limited in areal extent to the vicinity of CP08-PZM008.

Concentrations of benzene and naphthalene in sediment pore water were above the secondary chronic values for narcosis effects as listed in "Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants" (EPA, 2017) in sample locations off the western shore in the Cell 2 area, within the cove in the Cell 3 area, and in the Turning Basin east of the Cell 5 area.

Surface water samples confirmed the absence of any significant surface water concentrations of site-related COCs at most offshore locations around the CPA. However, benzene was detected above the ambient water quality criterion for human consumption of aquatic organisms in some samples from the cove area south of Cell 3. The extent of the exceedances was limited to the inland area of the cove, and surface water concentrations were below the ambient water quality criterion within a reasonable mixing zone distance and before the cove opened to the Patapsco River.

Previous investigations identified a few data gaps to be addressed to facilitate the CMS, including the availability of current groundwater data in Parcel B11, groundwater data for the Coke Point Landfill collected and analyzed under the "Quality Assurance Project Plan" (QAPP), the effect of pumping at the graving dock on groundwater flow, and the source of the elevated naphthalene identified in COR-MWI. Additional investigations were conducted as proposed in the CPA Groundwater Corrective Measures Study Work Plan (CMS Work Plan), Revision 0, dated October

18, 2019 to address these data gaps. This investigation and the results are detailed in the Coke Point Area Corrective Measures Study Investigation Report, which was originally submitted on October 22, 2020. Agency comments on this report were received in a December 15, 2020 email. In these comments, EPA states that it has determined that groundwater impacts are sufficiently characterized to conduct the Corrective Measures Study. A revised Coke Point Area Corrective Measures Study Investigation Report (Revision 1) addresses these comments.

# 3.0 PURPOSE

## 3.1 Overall Purpose of the Corrective Measures Study

This CMS will address groundwater impacts and sources of continuing releases to groundwater, which may include NAPL or impacted soil, associated with the Coke Point Area (CPA), including the Coke Oven Area and Coke Point Landfill Special Study Areas. Other soil impacts and potential exposures will be addressed through separate Phase II investigations and Response and Development Work Plans (RADWPs). Assessment and remediation of historical offshore impacts is being undertaken by the EPA and is not within the scope of this CMS.

## 3.2 Approach for Corrective Measures Study

The groundwater concern is volatile and semi-volatile organic compounds in the shallow and intermediate zone groundwater. The approach to addressing groundwater during the CMS is to:

- identify sources that need to be controlled to prevent cross-media transfer to groundwater (e.g., soil to groundwater),
- develop and evaluate alternatives to control continuing release of COCs to groundwater from identified source areas, and
- develop and evaluate alternatives to reduce levels of COCs in groundwater to the extent practicable and migration of contaminated groundwater across the shoreline/property boundary.

As noted, the CMS will address continuing discharges of groundwater but will not address impacts already present offshore. These pre-existing offshore impacts are being addressed separately by the EPA. The CMS will also evaluate exposure control measures (e.g., institutional and engineering controls). These measures will be evaluated relative to their ability to control exposure in the short-term, while other measures work towards the reduction of contaminant levels and extent over time.

# 4.0 CORRECTIVE MEASURES OBJECTIVES

## 4.1 CORRECTIVE ACTION OBJECTIVES (CAOS)

EPA expects final remedies to return usable groundwater to its maximum beneficial use, where practicable, within a timeframe that is reasonable. Where returning contaminated groundwater to its maximum beneficial use is not technically practicable, EPA generally expects facilities to prevent or minimize the further migration of a plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. Technical impracticability (TI) for contaminated groundwater refers to a situation where achieving groundwater cleanup levels associated with final cleanup standards is not practicable from an engineering perspective. The term "engineering perspective" refers to factors such as feasibility, reliability, scale or magnitude of a project, and safety.

CAOs for the CPA are defined as follows:

(1) control further releases of constituents of potential concern (COPCs) to the groundwater to the extent practicable,

(2) control human exposure to the hazardous constituents remaining in the groundwater,

(3) ensure that groundwater containing elevated concentrations of COPCs will not adversely impact ecological receptors nor adjacent surface water and pore water quality, and

(4) return contaminated groundwater to cleanup levels based on its maximum beneficial use, to the extent practicable.

## 4.2 TARGET MEDIA CLEANUP LEVELS

Target Media Cleanup Levels and points of compliance will be developed during the CMS. The CMS will propose media cleanup levels appropriate for the proposed CAOs and prepare figures to identify the locations and extents of exceedances of the proposed media cleanup levels. Potentially applicable standards and relevant criteria, and preliminary target levels and points of compliance are discussed below.

EPA prepared a groundwater use determination memorandum dated April 13, 2018 (Appendix A). EPA concluded that drinking water use of groundwater in the shallow and intermediate aquifers at Sparrows Point can be excluded from consideration when developing groundwater cleanup levels. The memorandum indicated that maximum beneficial use is industrial, commercial or dewatering and that groundwater cleanup levels should be developed based on State surface water quality criteria. The memorandum also indicated that more stringent groundwater cleanup levels may be appropriate in specific areas of the Sparrows Point Site, based on other potential exposures or pathways not associated with groundwater use (e.g., vapor intrusion or direct contact during construction excavation).

There is currently no direct exposure to groundwater for human receptors. Onsite industrial workers may be exposed to vapors through vapor intrusion to indoor air, and construction workers may have short-term exposure to shallow groundwater during intrusive work. Offsite ecological receptors may have long-term exposure to pore water impacted by groundwater migration.

Therefore, with respect to potential human exposure, groundwater cleanup levels will be derived for any constituents that might present an unacceptable risk due to vapor intrusion or to direct contact during construction excavation or under a worst-case hypothetical commercial/industrial exposure, such as the use of groundwater for equipment washing. The point of compliance for these cleanup levels would be Site-wide.

With respect to current industrial use (Graving dock dewatering) or potential industrial use and discharge of groundwater to surface water, groundwater cleanup levels will be developed based on State surface water quality criteria. These levels would serve as the target cleanup levels for restoration of groundwater to its maximum beneficial use and would apply Site-wide. The CMS will evaluate a surface water mixing zone in deriving these cleanup levels.

To protect ecological receptors, groundwater cleanup levels will be derived with a point of compliance at the shoreline/property boundary to ensure that groundwater discharge will not result in unacceptable risks to ecological receptors inhabiting the waters surrounding the CPA. Various toxicological benchmarks, including the BTAG marine screening benchmark for benzene, the marine NOEC for DRO, and secondary chronic values for narcosis effects for naphthalene, as well as other relevant aquatic screening criteria, will be considered, along with consideration of the quality and size of the potentially exposed habitat areas, in determining acceptable COPC concentrations applicable to specific exposure units. The CMS will evaluate attenuation factors for groundwater to surface water and shallow pore water to determine appropriate shoreline groundwater cleanup levels..

The CMS report will include figures presenting the distribution of contaminant concentrations exceeding these target media cleanup levels.

# 5.0 CORRECTIVE MEASURES TECHNOLOGIES

This section of the CMS Work Plan presents a description of the technologies planned for evaluation in the CMS. The technologies presented include those technologies considered applicable in addressing Facility contaminants, are likely to perform reliably and, will achieve the CAOs presented in Section 4.0 of this CMS Work Plan.

The potential groundwater remediation technologies to be evaluated include:

Institutional and Engineering Controls
- Restrictions on Groundwater Use
- Restrictions on Site Use
- Fencing/Warning Signs/Access Restrictions
- Capping Waste or Contaminated Soils

Removal Technologies
- Excavation
- Product Recovery (Skimmers, EFR)
- Groundwater Recovery (pump and treat)

Containment Technologies
- Hydraulic Containment
- Vertical Barrier Walls (sheet piling, soil-bentonite, etc.)
- Sub-slab Vapor Barrier and/or Venting

Treatment Technologies
- Air Sparge/Soil Vapor Extraction
- In-Situ Chemical Oxidation (reagent injection, deep soil mixing)
- In-Situ Biological Treatment (sulfate reduction)
- In-Situ Thermal Treatment (STAR)
- Ex-Situ Treatment (CAMU)
- Permeable Reactive Barriers

Disposal Technologies
- Off-Site Disposal/Landfilling
- On-Site Disposal (CAMU)
- Permitted Discharge

A screening of these technologies will be presented in a summary table describing each technology screened and the results of the screening to indicate which technologies are considered to be potentially applicable based on applicability to the target COCs and the implementability of the technology under the site conditions.

# 6.0 IDENTIFICATION AND EVALUATION OF ALTERNATIVES

This section of the CMS Work Plan presents a general description of the approach for identifying and evaluating potential corrective measure alternatives. Per applicable guidance, this section of the CMS will present a description of each alternative and a brief screening of the identified corrective measure alternatives against the RCRA threshold criteria.

## 6.1 Identification of Corrective Measure Alternatives

Those technologies determined to be potentially applicable will be developed into Corrective Action Alternatives. Identified technologies may be used alone or in combination to form the overall corrective measure alternatives. The CMS may identify a current interim measure as, or as part of, a final corrective measure alternative.

The CMS will describe the components of each corrective measure alternative including an engineering description of each corrective measure alternative, a conceptual level design that will form the basis for the estimate of potential cost for that alternative, how the alternative may be expected to perform and, expectations regarding the time-frame for remediation.

These alternatives will be screened against RCRA's threshold criteria which are:

1. protection of human health and the environment;
2. attainment of media cleanup objectives; and
3. controlling the sources.

## 6.2 Additional Data Collection

No pilot or bench scale studies are currently anticipated. If an in-situ treatment technology is identified for detailed evaluation, bench-scale treatability testing may be performed to assess the efficacy and dosing of potential reagents.

## 6.3 Evaluation of Corrective Measure Alternative(s)

This section will present a detailed evaluation of those alternatives determined to meet the threshold criteria. Pursuant to applicable CMS guidance, the evaluation will address each of the following evaluation/balancing criteria: long-term effectiveness; implementability; short-term effectiveness; toxicity, mobility and volume reduction; community acceptance; state acceptance; and cost.

### 6.3.1 Long-Term Effectiveness

This criterion refers to the expected effectiveness, reliability and risk of failure of the alternatives, including the effectiveness under analogous site conditions, the potential impact resulting from a failure of the alternative, and the projected useful life of the alternative.

### 6.3.2 Reduction in Toxicity, Mobility, or Volume of Wastes

This criterion generally refers to how much the corrective measures alternatives will reduce the waste toxicity, mobility and/or volume, primarily through treatment.

### 6.3.3 Short-Term Effectiveness

This criterion generally refers to potential short-term risks to on-site workers and the community in association with implementation of the corrective measure alternatives, such as might be associated with the excavation, handling, treatment, containment, and transportation of contaminated materials.

### 6.3.4 Implementability

This criterion refers to the relative ease of alternative implementation (construction), including duration, administrative and technical feasibility, and availability of the required services and materials.

### 6.3.5 Community Acceptance

This criterion refers to the known or anticipated community acceptance associated with the corrective measure alternatives. This criterion will be further evaluated through the 30-day public comment period that will be provided following remedy selection and issuance of a Statement of Basis by the EPA.

### 6.3.6 State Acceptance

This criterion refers to how the corrective measure alternatives will comply with applicable State regulations (e.g., permit requirements).

### 6.3.7 Cost

This criterion addresses the anticipated short- and long-term costs associated with implementation of the corrective measure alternatives.

# 7.0 REPORT OUTLINE

The outline for the report is expected to be generally as follows:

1.0 INTRODUCTION
2.0 DESCRIPTION OF CURRENT SITUATION
- 2.1 Summary of Previous Investigations
- 2.2 Source Areas
- 2.3 Nature and Extent of Groundwater Impacts
- 2.4 Interim Measures

3.0 CORRECTIVE ACTION OBJECTIVES
- 3.1 Corrective Action Goals
- 3.2 Media Cleanup Levels and Point(s) of Compliance

4.0 IDENTIFICATION AND DEVELOPMENT OF THE CORRECTIVE MEASURES ALTERNATIVES
- 4.1 Screening of Corrective Measures Technologies
- 4.2 Identification of the Corrective Measures Alternatives
- 4.3 Detailed Description of Each Alternative
  - 4.3.1 Protection of Human Health and the Environment
  - 4.3.2 Attainment of Media Cleanup Objectives
  - 4.3.3 Control of Sources of Releases
- 4.4 Initial Screening of Alternatives

5.0 EVALUATION OF CORRECTIVE MEASURES ALTERNATIVES
- 5.1 Detailed Evaluation of Alternative 1
  - 5.1.1 Long-Term Effectiveness
  - 5.1.2 Reduction in Toxicity, Mobility, or Volume of Wastes
  - 5.1.3 Short-Term Effectiveness
  - 5.1.4 Implementability
  - 5.1.5 Community Acceptance
  - 5.1.6 State Acceptance
  - 5.1.7 Cost
- 5.2 Alternative 2
- 5.3 Alternative 3, …

6.0 COMPARATIVE ANALYSIS AND PREFERRED ALTERNATIVE
- 6.1 Comparison of Alternatives
- 6.2 Technical Impracticability Assessment
- 6.3 Recommended Alternative

## 6.4 Preliminary Implementation Schedule

# 8.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

## 8.1 PROJECT PERSONNEL

The Work Plan will be implemented by ARM Group Inc. (ARM) under a contract with Tradepoint Atlantic (TPA).

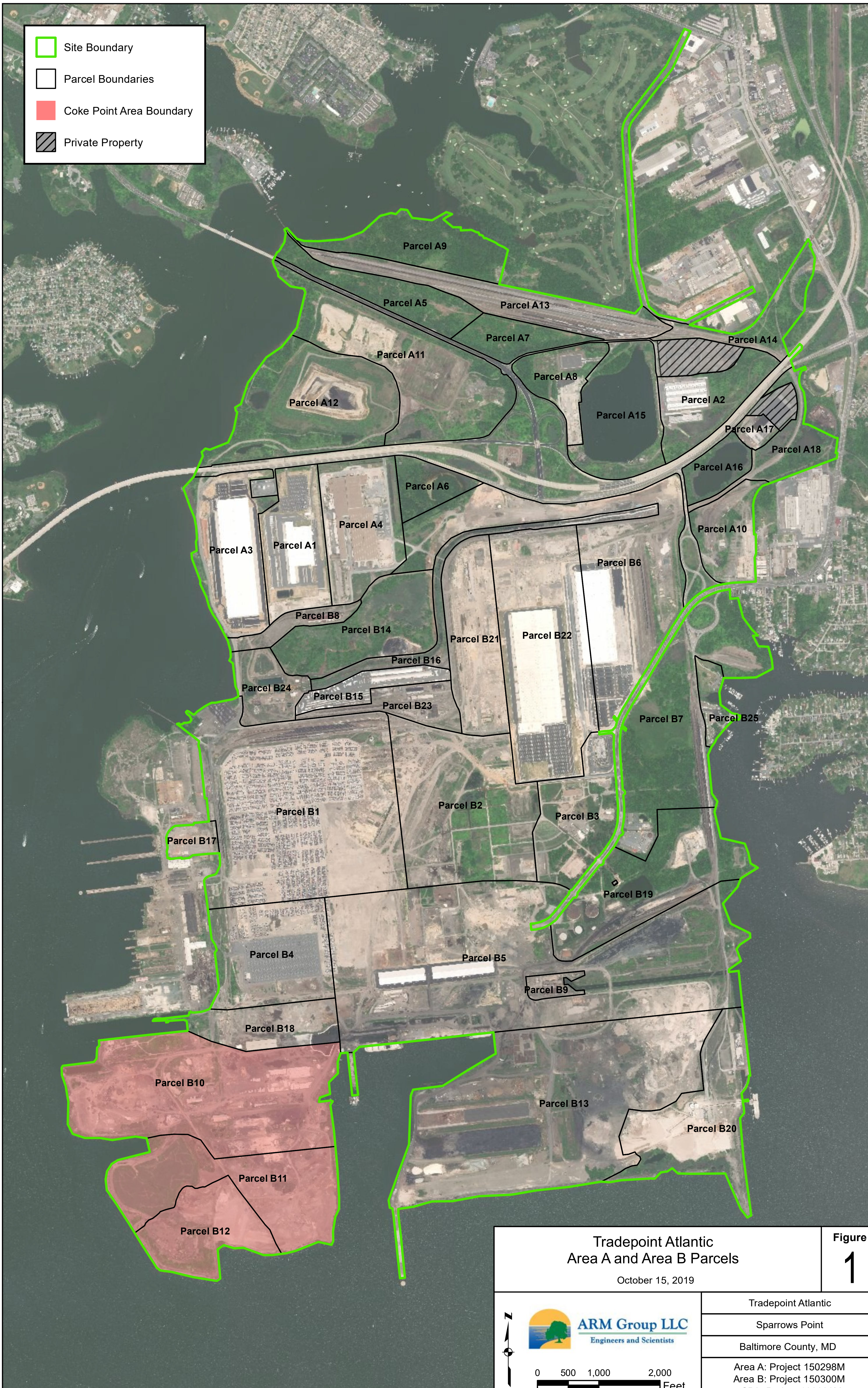
The TPA Project Manager is Mr. Peter Haid. Mr. Haid will be responsible for ensuring the availability of resources for the project and will be the primary point of contact with the regulatory agencies.

The ARM Project Manager, Mr. Neil Peters, P.E., is responsible for ensuring that all activities are conducted in accordance with this Work Plan and the contract requirements. Mr. Peters is a registered Professional Engineer in the State of Maryland and has served as Project Manager on numerous remediation projects. As Project Manager, Mr. Peters will be responsible for technical direction of ARM's team of engineers and geologists, directing daily project activities, tracking project schedule, and providing quality assurance. Mr. Peters will provide technical coordination with the MDE, EPA and TPA.

## 8.2 PROJECT SCHEDULE

The additional data collection is anticipated to require approximately 12 weeks after agency approval. The anticipated schedule for completion of the CMS report is 8 weeks following the receipt of the data from the additional data collection. If, after screening of technologies, it is determined that bench-scale or pilot-scale testing is necessary, additional time may be required and a proposed schedule will be submitted.

# FIGURES



Site Boundary
Parcel Boundaries
Coke Point Area Boundary
Private Property
Parcel A9
Parcel A5
Parcel A13
Parcel A7
Parcel A14
Parcel A11
Parcel A8
Parcel A12
Parcel A2
Parcel A15
Parcel A17
Parcel A18
Parcel A16
Parcel A6
Parcel A4
Parcel A10
Parcel A3
Parcel A1
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Parcel B21
Parcel B22
Parcel B16
Parcel B24
Parcel B15
Parcel B23
Parcel B7
Parcel B25
Parcel B1
Parcel B2
Parcel B3
Parcel B17
Parcel B19
Parcel B4
Parcel B5
Parcel B9
Parcel B18
Parcel B10
Parcel B13
Parcel B20
Parcel B11
Parcel B12
Tradepoint Atlantic
Area A and Area B Parcels
October 15, 2019
Figure
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ARM Group LLC
Engineers and Scientists
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Feet
Tradepoint Atlantic
Sparrows Point
Baltimore County, MD
Area A: Project 150298M
Area B: Project 150300M
CPA: Project 190686M


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ARM Group LLC
Engineers and Scientists

1 inch = 650 feet

0 325 650 Feet

Coke Point Area
Parcel Boundaries
Aerial Imagery

**Figure 2**


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ARM Group LLC
Engineers and Scientists

1 inch = 650 feet

0 325 650
Feet

Coke Point Area
Interim Measures Cells
Aerial Imagery

**Figure 3**

# APPENDIX A

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION III**
**1650 Arch Street**
**Philadelphia, Pennsylvania 19103-2029**

| | | |
|---|---|---|
| **SUBJECT:** | Groundwater Use Determination<br>Sparrows Point Site (Tradepoint Atlantic)<br>Sparrows Point, MD<br>MDD053945432 | April 13, 2018 |
| **FROM:** | Erich Weissbart, P.G.<br>Project Manager<br>Office of Remediation | |
| **TO:** | Luis Pizarro<br>Associate Director<br>Office of Remediation | |

**Introduction**

The purpose of this memo is to establish the basis for determining the maximum beneficial use of groundwater at the Sparrows Point Site located in Sparrows Point, MD. This determination is necessary to select appropriate groundwater cleanup objectives for the facility under the Resource Conservation and Recovery Act (RCRA) Corrective Action program.

EPA policy for groundwater cleanup at RCRA Corrective Action facilities is to return usable groundwater to its maximum beneficial use in a timeframe that is reasonable given the circumstances of the site. A determination of maximum beneficial use is based on how groundwater is actually used or could be used, and should also be based on the hydrogeologic and geochemical characteristics of the groundwater aquifer. EPA prefers to rely on State groundwater use determinations, but can use its own in the absence of a State determination. The policy applies to impacted aquifers beneath a Corrective Action facility, however there are sites where it applies offsite as a result of migrating contaminant plumes. The majority of RCRA Corrective Action facilities are required to restore contaminated groundwater to levels acceptable for drinking, since drinking water is generally the most beneficial use of groundwater, requiring the lowest cleanup levels. However, groundwater cleanup levels can also be based on other uses and exposures, or to protect surface water to which groundwater discharges.

Without a formal aquifer use determination at the Sparrows Point facility, EPA's presumption is that the groundwater is usable as drinking water and must be restored to drinking water standards. Likewise, Maryland Department of the Environment Interim Final Guidance, Cleanup Standards for Soil and Groundwater (June 2008) defines aquifers of the State as Type I and Type II, which would also require the groundwater beneath Sparrows Point be restored to drinking water standards. The remainder of this memorandum is to present the basis for excluding drinking water use from consideration at Sparrows Point and thereby establish alternative uses upon which to base groundwater cleanup levels. This groundwater use determination applies to impacted groundwater from immediately below the land surface at Sparrows Point, called "shallow" in historical reports, and groundwater immediately beneath the shallow called "intermediate" in historical reports. This document will define the depths of these two aquifers, the basis for the determination, and the basis for limiting the determination to the shallow and intermediate aquifers. Once this determination is made and accepted by stakeholders, groundwater cleanup levels will be proposed in a Statement of Basis (SB) proposing a remedy for sitewide groundwater. Once the usage determination and groundwater cleanup objectives are proposed, both will go through public participation as part of the proposed remedy decision for groundwater.

If groundwater use as drinking water is excluded as a basis for setting cleanup levels, an important component of final remedies is to establish institutional controls that prevent the usage of groundwater for potable use. Restrictions can be placed on the land using enforceable controls (e.g., with environmental covenants) preventing the installation of any types of wells other than monitoring wells, preventing the use of groundwater for anything other than monitoring and cleanup, or requiring treatment before use or discharge. However, the groundwater must still ultimately be restored to the cleanup objectives established for other potential uses and exposures, or attempts made to achieve the groundwater cleanup levels.

**Background**

Sparrows Point is a unique RCRA site in that that it is much larger than most, greater than 3,000 acres in areal extent, and it is surrounded by water on three sides. Sparrows Point is a peninsula, bounded to the east by Old Road Bay and Jones Creek; to the south and west by the Patapsco River; and to the northwest by Bear Creek, all of which directly or indirectly drain into the Chesapeake Bay. Throughout most of the peninsula, the elevation of the ground surface is between 10 and 20 feet above mean sea level (amsl). Surface water runoff is diverted and collected by a network of culverts, underground pipes, and drainage ditches within former process areas. Storm water is then discharged to Bear Creek, Jones Creek/Old Road Bay, and the Patapsco River under existing National Pollutant Discharge Elimination System (NPDES) discharge permits.

In 1887 Maryland Steel built an iron furnace on the Facility, and the first iron was cast in 1889. The Bethlehem Steel Corporation (BSC) purchased the property in 1916 and enlarged it, building mills to produce hot rolled sheet, cold rolled sheet, galvanized sheet tin mill products, and steel plate. During peak production in 1959, BSC operated 12 coke oven batteries, 10 blast furnaces, and four open hearth furnaces. The land no longer resembles that which was initially encountered prior to construction of the steel mill in the late 1800's, nor does the Facility resemble that which terminated steel making in 2012.

## Geology and Hydrogeology

The Sparrows Point Facility lies within the Atlantic Coastal Plain physiographic province. This province is characterized by a relatively thick wedge of alternating layers of sand, gravel, silt, and clay sediments. Near Baltimore, these unconsolidated sediments are primarily of Cretaceous age, but at Sparrows Point are overlain by up to 125 feet of later Pleistocene sediments. These complexly stratified deposits comprising the Atlantic Coastal Plain form an inter-layered sequence of aquifers and confining beds in a thickening wedge from the "fall line" to the southeast. The lithology, permeability, and structure of the sediments define the geologic setting and provide the framework for the groundwater-flow system. The geologic setting controls the occurrence, movement, and quality of groundwater. Predominantly sandy and gravelly layers, capable of yielding water, form aquifers, while fine-grained layers (silts and clays) impede the flow of groundwater and form confining units.

Stratigraphy at the site from deepest to shallow begins with crystalline basement rocks that are unconformably overlain by the Patuxent Formation, which is conformably overlain by the Arundel Formation. The Arundel Formation is disconformably overlain by the Patapsco Formation, which represents uppermost Cretaceous-age sediments. The Patuxent, Arundel, and Patapsco Formations are collectively called the Potomac Group. Pleistocene sediments of the Talbot Formation unconformably overlie the Cretaceous sediments. The thickness of the Atlantic Coastal Plain sediments vary across the site but notably, for the purpose of this memorandum, the shallow, intermediate, and deep aquifers investigated at Sparrows Point comprise sediments approximately 220 feet to 270 feet thick and are underlain by the Arundel Formation. The Arundel Formation, or Arundel Clay, is the middle unit of the Potomac Group. In the Baltimore area, it is a red to red-yellow, dense, plastic clay with thin lenses of silt. The Arundel Clay completely confines the Patuxent Formation and subsequent aquifers beneath.

Land reclamation and fill placement have occurred at the Facility since the early 1900s. In general, stream channels and estuaries that originally extended into the Sparrows Point peninsula were filled; the southern shoreline of the peninsula was expanded southward into the Patapsco River with fill; and fill was used to create level grades (Figure 1). The fill deposits are thickest (up to 40 feet) in the historic stream channels and estuaries, particularly Humphrey Creek, Greys Creek, Jones Creek, and Old Road Bay and in the two landfill areas, including Greys Landfill and Coke Point Landfill, where fill thickness may be as thick as 70 feet. More recent fill deposits are entirely manmade and were related to land reclamation associated with the expansion and development of the facility. The fill deposits consist primarily of iron- and steel-making slag. Because of its extensive presence across the Sparrows Point site, these manmade fill deposits are called the Slag-Fill Unit.

The Slag-Fill Unit is the uppermost hydrostratigraphic unit at the site. The shallow water table occurs within the Slag-Fill Unit, and groundwater within the Slag-Fill Unit is unconfined. In some areas the Slag-Fill Unit is directly underlain by and connected to the coarser grained beds or lenses within the Pleistocene Talbot Formation that comprise the Upper Talbot Channel Unit. In these areas, the Slag-Fill and Upper Talbot Channel Units form a single groundwater flow system. In much of the site, the Slag-Fill unit is underlain by finer-grained silts and clays that comprise the Talbot Clay Aquitard. In these areas, groundwater flow in the Slag-Fill Unit is separated from groundwater flow in any underlying coarse-grained beds or lenses. Wells designated as shallow are screened within the slag/fill unit. The “shallow” bottom-of-screen elevations generally range from +5 to -20 feet amsl.

The thickness of the Talbot deposits (125 feet in the Sparrows Point area) may indicate an area of deeper paleo-channel erosion and subsequent backfill. The intermediate hydrogeologic zone includes the unconfined to partially confined groundwater in the Upper Talbot unit. The “intermediate” bottom-of-screen elevations generally range from -20 to -50 feet amsl. The presence of clay and silt layers within the intermediate hydrogeologic zone likely retard the vertical recharge of groundwater from the upper fill material.

The lower hydrogeologic zone includes the confined groundwater in the Lower Talbot or Upper Patapsco Sand unit. At Sparrows Point the Patapsco Formation has been interpreted to have a thickness of up to 255 feet. The “lower” bottom-of-screen elevations generally range from -50 to -141 feet amsl. Hydrogeologic zones at greater depth are known to exist based on a review of the regional geology; however, these deeper units are isolated from the upper three units by the Arundel Clay and impacts have not been identified from former operations.

Aquifers in the Patuxent and Patapsco Formations are the primary groundwater sources in the Baltimore area. Local water supplies can be produced from the Talbot Formation, however where the Talbot Formations outcrop close by to estuaries, nearby water supply wells are susceptible to chloride contamination. No municipal water supply wells are located on the Sparrows Point peninsula. Elevated chloride concentrations in the Talbot Formation are wide-spread along the Patapsco River and its estuaries, and salt-water encroachment is a significant factor limiting the development of water supplies in the Talbot Formation. Groundwater recharge to the Talbot Formation occurs primarily through the percolation of local precipitation to the water table. It is estimated that approximately 10 inches of rainwater per year recharges the surficial shallow water table aquifer. Discharge is primarily by natural means to springs and surface waters of local rivers, streams, and estuaries.

The Patapsco Formation is also a source of groundwater for the Baltimore area. A sand facies in the lower part of the Patapsco Formation is considered the principal source of water for the Patapsco aquifer. The Patapsco aquifer is confined at Sparrows Point by the overlying Pleistocene Talbot sediments that serve as the upper confining bed, and the Arundel Formation defines the lower confining bed.

The Patapsco aquifer was used as a source of groundwater prior to 1900 and during the early part of the 20th century. Because the Patapsco aquifer widely subcrops beneath the brackish Patapsco River, elevated chloride concentrations became a major problem in areas near the Patapsco River estuary. By 1945, almost all water production from the Patapsco had ended due to excessive chloride near the Harbor, Canton, and Dundalk areas. The BSC plant was the only major user of the Patapsco aquifer in 1945. Water production totaled about 3 million gallons per day (Mgal/d); however, by the later 1940’s and 1950’s, many of the Sparrows Point wells were affected by elevated levels of chlorides and were abandoned. As of 1985, there were no major use of the Patapsco aquifer in the immediate vicinity of the Patapsco River estuary.

## Usage

*Current*

There is no current ongoing usage of groundwater beneath the Facility, but there is groundwater extraction at an adjacent property as described below. Groundwater is monitored for various purposes on a regular frequency to assess remediation efforts at the former Rod and Wire Mill and Coke Oven Area.; regular groundwater monitoring also occurs at Greys Landfill. Across the entire Sparrows Point facility there are dozens to hundreds of monitoring wells constructed into the shallow aquifer and a lesser number into the intermediate aquifer. There are few monitoring wells constructed into the deeper aquifer. There are no monitoring wells into the Arundel Formation and none into the Patuxent below the Arundel. There are six deep production wells constructed into the Patuxent, but none are currently in use.

An adjacent property called Sparrows Point Shipyard (Shipyard) contains a "graving dock," used for the repair or scrapping of ships under dry conditions. Ships enter the graving dock when it is filled with water, via the Patapsco River, and then a gate is closed and water is removed. A central feature of the graving dock is the underdrain pumping system. The underdrain pumping system collects groundwater and pumps the water to the Patapsco River. The Shipyard's pumping system causes groundwater from the Coke Oven Area of Sparrow's Point to flow towards the graving dock. The discharge of the water from the underdrain pumps to the Patapsco River is regulated by the Clean Water Act; specifically by a NPDES discharge permit issued by MDE.

Because of sampling performed by MDE in 2005 where high concentrations of benzene were detected in the discharge, a 2006 permit renewal included a discharge limit of 0.51 mg/1 on benzene in certain graving dock discharges that applied to dewatering/trim pumps, and not to the underdrain pumping system. In January 2009, MDE revised the permit to impose the same 0.51 mg/1 limit to the underdrain pump discharge, and the revision went into effect in February 2010. To comply with the benzene limitation, the Shipyard installed a benzene treatment system that removes benzene from the groundwater.

The Shipyard operates the water treatment system to remain within the 0.51 mg/1 benzene limit imposed by MDE, however the need for the treatment is caused by the operation of the graving dock. The Shipyard pump systems remove an average rate of 750 gallons per minute (i.e. roughly 1.08 Mgal/day). The influence from the dewatering system at the graving dock on water levels in the intermediate zone of groundwater in the Coke Oven Area is depicted on the potentiometric figures created from monitoring well water levels measured over time and submitted by the Facility in investigations and progress reports. Influence on the shallow zone of groundwater is not apparent. This condition is attributed to: location of the pumps at depths that correspond with the stratigraphy of the intermediate unit and decreased recharge from the Patapsco River, and the partially-confined condition of the intermediate zone in this area. The spread of a cone of depression from a pumping center under partially-confined conditions occurs more quickly than that under unconfined conditions. The influence of the graving dock pumping is observable over 2,000 feet away, where flow in the Coke Oven Area is shifted to the northwest in the intermediate zone, while flow in the shallow zone is to the southwest.

*Potential Future Usage*

Groundwater beneath the Sparrows Point Facility has value as a resource whether it is potable use or another use. How groundwater could be used depends upon multiple factors: vulnerability to contamination; hydrogeologic regimes (recharge and discharge areas); flow patterns; quantity and potential yield; ambient and/or background quality; and existing contamination are some[1]. If each factor were addressed satisfactorily (e.g. sufficient quantity and yield and absence of contamination) then the groundwater could potentially be a potable source. However, if some factors were met successfully and others were not the groundwater could still have potential uses. The following list of groundwater uses was collected from the United States Geologic Survey and MDE:

1. **Public and domestic supply** - water used for indoor and outdoor household purposes—all the things you do at home: drinking, preparing food, bathing, washing clothes and dishes, brushing your teeth, watering the yard and garden.
2. **Aquaculture** water use is water associated with raising creatures that live in water—such as finfish and shellfish—for food, restoration, conservation, or sport.
3. **Industrial** water use includes water used for purposes such as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. Some industries that use large amounts of water produce such commodities as food, paper, chemicals, refined petroleum, or primary metals.
4. **Irrigation** water is essential for keeping fruits, vegetables, and grains growing. Throughout the world, irrigation (water for agriculture, or growing crops) is probably the most important use of water. Estimates vary, but about 70 percent of all the world's freshwater withdrawals go towards irrigation uses (http://www.globalagriculture.org/report-topics/water.html). Large-scale farming could not provide food for the world's large populations without the irrigation of crop fields by water gotten from rivers, lakes, reservoirs, and wells.
5. **Livestock** water use is water associated with livestock watering, feedlots, dairy operations, and other on-farm needs. Livestock includes dairy cows and heifers, beef cattle and calves, sheep and lambs, goats, hogs and pigs, horses, and poultry. Other livestock water uses include cooling of facilities for the animals and animal products such as milk, dairy sanitation and wash down of facilities, animal waste-disposal systems, and incidental water losses.
6. **Mining** water use is water used for the extraction of minerals that may be in the form of solids, such as coal, iron, sand, and gravel; liquids, such as crude petroleum; and gases, such as natural gas. The category includes quarrying, milling (crushing, screening, washing, and flotation of mined materials), and other operations associated with mining activities.

[1] Factors to Assess Use, Value, and Vulnerability from: Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action; EPA 530-R-04-030; April 2004. Current use and exposures (including public water supply systems and private drinking water supply wells); Reasonably expected future uses (based on demographics, remoteness, and availability of alternative water supplies; Connections to surface waters; Impacts to ecological receptors; Value attributed to a groundwater resource, including public opinion; Governmental and legal boundary considerations (e.g., groundwater migrating across State boundaries).

*Value*

Because of the native unconsolidated sediments where groundwater is resident on the peninsula there is groundwater available for the typical uses described above. It is reported that BSC previously extracted 3 Mgal/d from the Patapsco Aquifer and the Shipyard currently extracts approximately 1 Mgal/d from the intermediate aquifer located in the Talbot Formation. Equally apparent from the former and current usage is that unconsolidated sediments possess the hydrogeologic characteristics necessary to extract groundwater at a sustainable rate. Aquifer characteristics are less important, as are most of the factors, than an assessment of the background quality of the groundwater. Groundwater background quality is the most important factor because the shallow aquifer resides in iron/manganese bearing slag fill and because the Sparrow's Point peninsula is surrounded by brackish water.

Background is the condition of groundwater including water quality indicators prior to the introduction of anthropogenic contamination. Water quality standards, i.e. pH, turbidity, temperature, etc. are typically collected from monitoring wells prior to groundwater sample collection. The purpose of collecting water quality indicators is to establish that a monitoring well groundwater sample reflects the conditions of an aquifer and not the well bore. The water quality indicators are recorded as evidence of proper sample collection.

In this effort to assess groundwater usage at the Sparrow's Point site, EPA requested an evaluation of site-wide groundwater, including an analysis of pH and total dissolved solids (TDS), from the current property owners. The Site-Wide Groundwater Study Report, (EnviroAnalytics Group (EAG) August 17, 2017), was submitted in response and included the requested groundwater data for both the shallow and intermediate aquifers as detailed below.

The EAG Report included an evaluation of boring logs and well construction logs constructed in the shallow aquifer that identified groundwater monitoring locations completed in the slag fill. The purpose was to determine and map the thickness of slag fill within the saturated zone. The conclusion presented was that most of the locations where groundwater is present in slag fill are located beyond the historical 1916 shoreline (Figures 1 and 2).

A Site-Wide Investigation (SWI) report completed in 2001 by CH2M-Hill provided hydrogeological and general water quality data across the entire Sparrow's Point Facility and addressed a number of objectives. Data collected to meet the objectives were used to develop a site-specific groundwater flow model with particle tracking simulating contaminant flow (MODFLOW). Water quality data collected to address the objectives were TDS and chloride concentrations from shallow and deep zones for comparing groundwater quality and determining surficial and groundwater connectivity.

The chloride and TDS data from the SWI report were combined with specific conductance (SC) data collected during the routine sampling of monitoring wells as part of current ongoing parcel investigations. The SC data that was collected during parcel investigations was converted to equivalent TDS values (1000 uS/cm = 534 mg/L TDS). These data points were used to develop TDS isoconcentration maps for the shallow and intermediate groundwater (Figures 3 and 4).

Groundwater associated with slag fill can exhibit extremely basic pH concentrations rendering it unusable. pH values collected from recent sampling events from each well or piezometer were contoured to create maps (shallow and intermediate) showing pH contours and delineating areas of the site where the pH exceeds 10 (Figures 5 and 6). These areas/zones are not usable as potable aquifers, both due to the high pH and the occurrence of the groundwater in non-natural slag fill which additionally contributes iron and manganese.

Iron and manganese (Fe/Mn) are common in shallow and intermediate groundwater at Sparrows Point. Manganese was detected in 95% of groundwater samples and iron was detected in 94% of groundwater samples. High levels of iron and manganese do not pose any known adverse health risks and EPA has not set MCLs for iron and manganese; however there are Project Action Levels (PALs) established as screening levels for the Facility. Secondary maximum contaminant levels (SMCL) recommended in the National Secondary Drinking Water Regulations are set for aesthetic reasons and are not enforceable by EPA, but are intended as guides to the States. The SMCL for iron is 0.3 mg/L (site-specific PAL is 14 mg/L) and the SMCL for manganese is 0.05 mg/L (site-specific PAL is 0.43 mg/L). High levels of these contaminants can result in discolored water, stained plumbing fixtures, and an unpleasant metallic taste to the water. For groundwater samples collected at Sparrows Point, 47% exceeded site-specific PALs for manganese and 30% exceeded PALs for iron.

Saltwater intrusion was an issue at the Facility previously because of historical pumping for industrial water use. Data and analysis have been provided showing total dissolved solids and pH in groundwater across the site in the shallow and intermediate levels. Based on this data, (TDS and pH) shallow and intermediate groundwater is not suitable for potable use, primarily because of the largely man-made slag fill contributing elevated pH, Mn, and Fe, but also because of the connection to surface water and elevated chloride. The groundwater in these areas is not suitable for potable use. The table below summarizes the potential uses of groundwater in the shallow and intermediate zones, the potential cleanup standard that would have to be attained, and EPA's determination of usage.

| Designation | Standard | Shallow Use | Intermediate Use |
|---|---|---|---|
| Domestic Potable Supply and Residential Irrigation | MCLs | No. Shallow groundwater contains excess TDS and elevated pH | No. Intermediate groundwater contains elevated TDS. |
| Farming (Livestock Watering and Agricultural Irrigation) | Ecological RBC or other risk based std. | No. Shallow groundwater contains excess TDS and both low and high pH | No. Intermediate groundwater contains elevated TDS. |
| Industrial, Commercial, Dewatering (Mining, aquaculture) | State Surface Water Quality Discharge Standards | Yes. | Yes. Current dewatering at Sparrows Point Shipyard. |
| Public Water Supply Well | MCLs | No. Shallow groundwater contains excess TDS and both low and high pH | No. Intermediate groundwater contains elevated TDS. |
| Test, Observation, Monitoring | None | Yes | Yes |
| Open Loop Geothermal[2] | State Surface Water Quality Discharge Standards | yes | yes |

**Conclusion**

Based on the above analysis, EPA has determined that drinking water use of groundwater in the shallow and intermediate aquifers at Sparrows Point can be excluded from consideration when developing groundwater cleanup levels. Maximum beneficial use should include the uses outlined in the above table, and groundwater cleanup levels should be developed based on State surface water quality discharge standards. More stringent groundwater cleanup levels may be appropriate in specific areas of the Sparrows Point Site, based on other potential exposures or pathways not associated with groundwater use (e.g., vapor intrusion or direct contact during construction excavation).

[2] The evaluation of geothermal systems is beyond the scope of this memorandum. In the case where the Facility or a Parcel owner/lessee proposes to use groundwater for geothermal heating or cooling EPA will then assess the viability of the proposal.


| | | | | | |
|---|---|---|---|---|---|
| N<br>ARM Group Inc.<br>Earth Resource Engineers and Consultants<br>0 375 750 1,500 Feet | Site Boundary<br>Area A Boundaries<br>Area B Boundaries | Land<br>Marsh<br>Water | Approximate Shoreline 1916<br>July 19, 2017 | EnviroAnalytics Group | Tradepoint Atlantic | Figure<br>1 |
| | | | Adapted from Figure 2-5 of the Description of Current Conditions Report prepared by Rust Environmental and Infrastructure, dated January 1998 | Area A: Project 150298M<br>Area B: Project 150300M | Baltimore County, MD | |


ARM Group Inc.
Earth Resource Engineers and Consultants

# Site-Wide Groundwater Saturated Slag Thickness (ft)

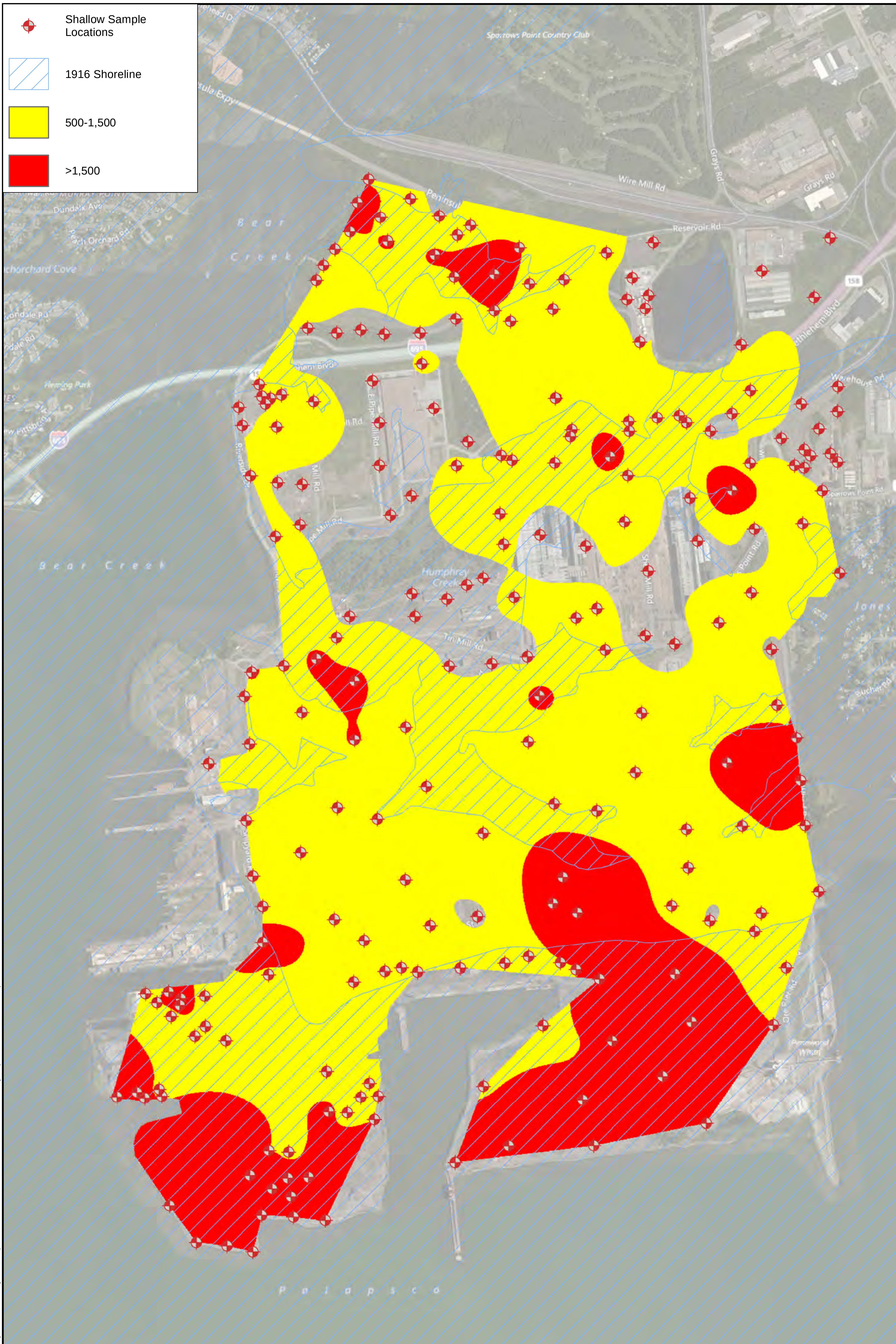
March 16, 2018

EnviroAnalytics Group

Tradepoint Atlantic
Baltimore County, MD

Figure
2

\\COLUMBIADC01\CorpData\Projects\EnviroAnalytics Group\170194M EAG Groundwater Conditions Summary Report\GIS\Site-wide GW pH and TDS.mxd




ARM Group Inc.
Earth Resource Engineers and Consultants

0 500 1,000 2,000
Feet

# Site-Wide Groundwater
# Shallow TDS Concentrations (mg/L)

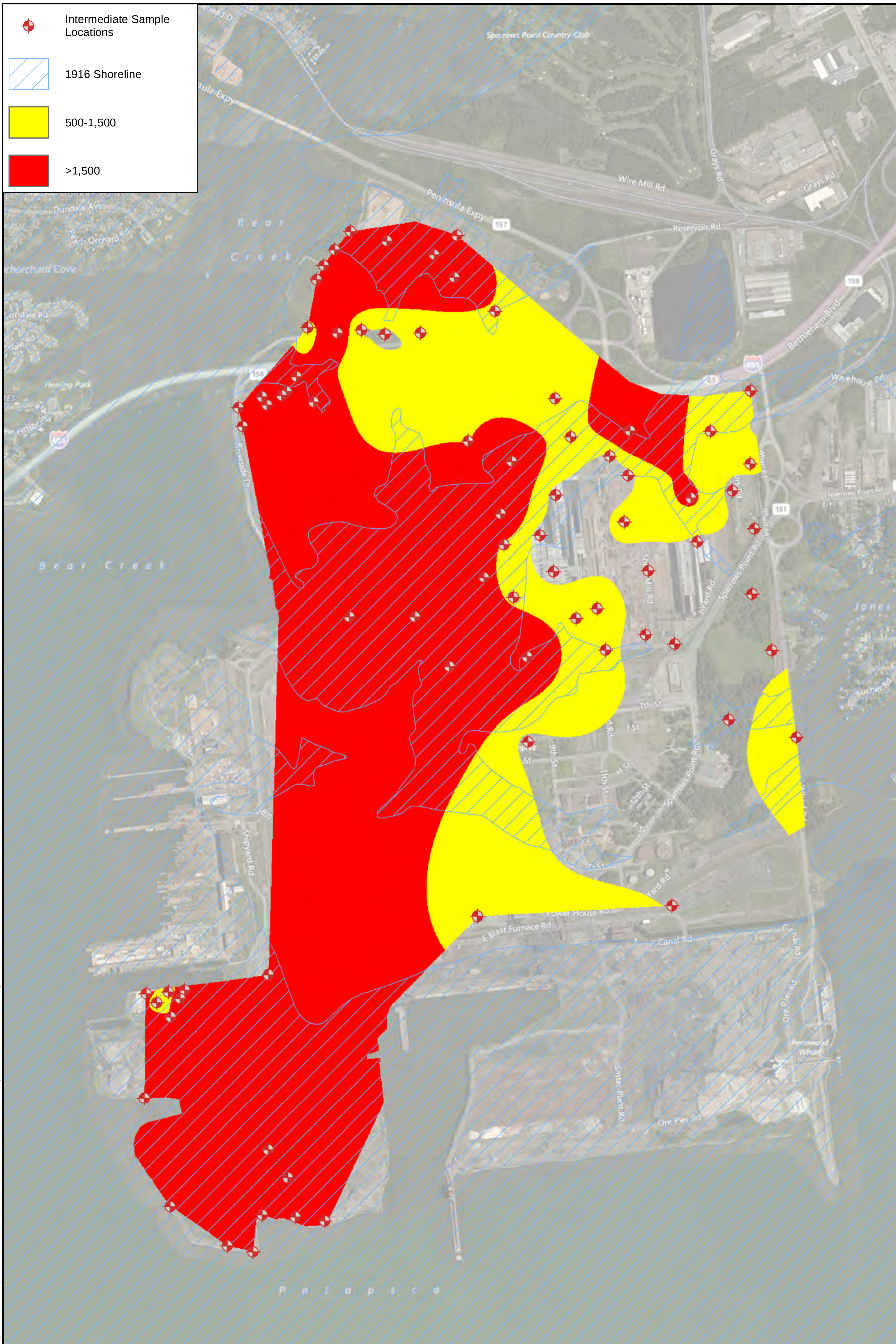
March 16, 2018

EnviroAnalytics Group

Tradepoint Atlantic
Baltimore County, MD

Figure
3

\\COLUMBIA\DC01\CorpData\Projects\EnviroAnalytics Group\170194M EAG Groundwater Conditions Summary Report\GIS\Site-wide GW pH and TDS.mxd

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ARM Group Inc. Earth Resource Engineers and Consultants

0 500 1,000 2,000 Feet

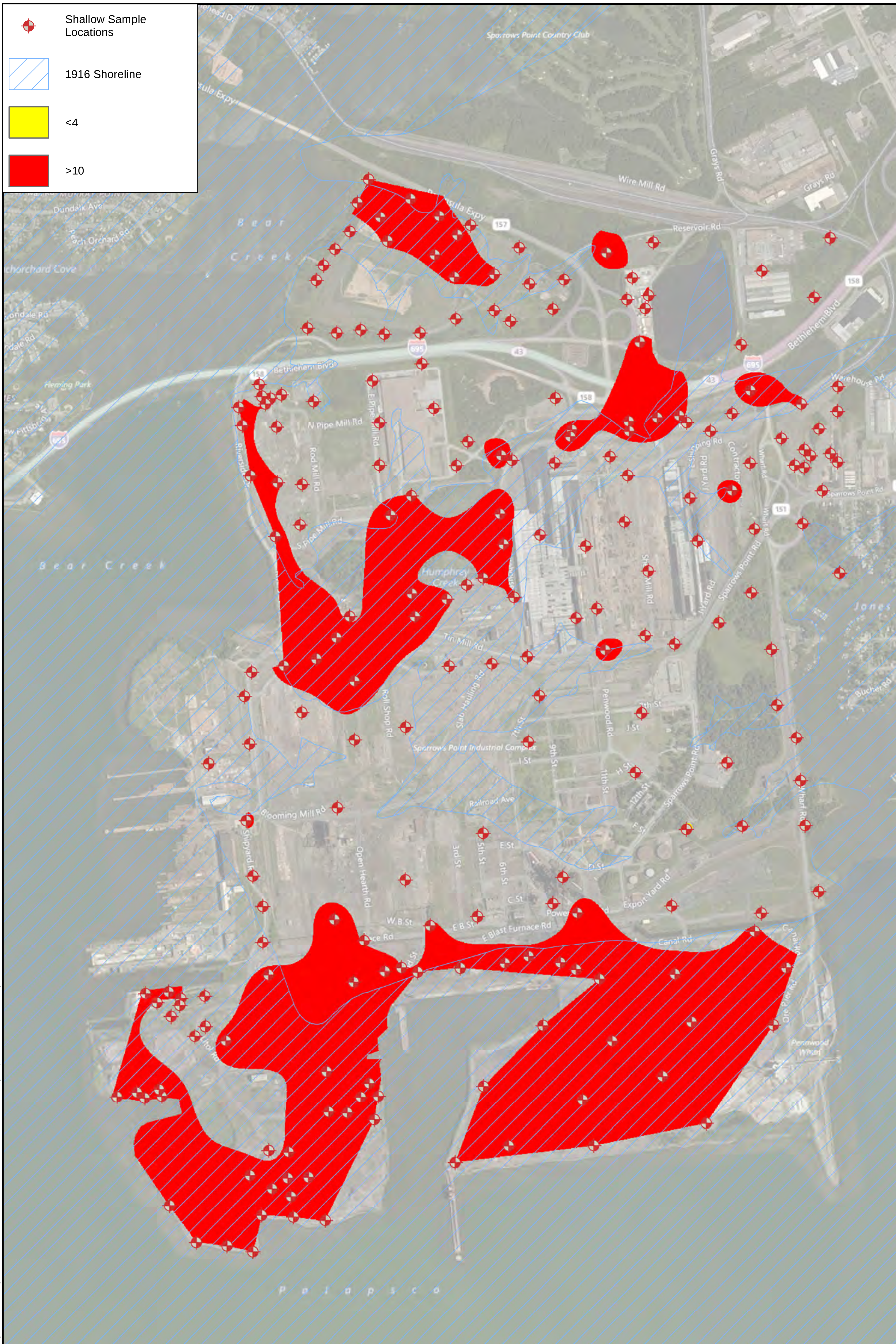
# Site-Wide Groundwater Intermediate TDS Concentrations (mg/L)

March 16, 2018

EnviroAnalytics Group

Tradepoint Atlantic
Baltimore County, MD

Figure 4




| ARM Group Inc. Earth Resource Engineers and Consultants<br>0 500 1,000 2,000 Feet | Site-Wide Groundwater<br>Shallow pH Concentrations<br>March 16, 2018 | EnviroAnalytics Group<br>Tradepoint Atlantic<br>Baltimore County, MD | Figure<br>5 |
|---|---|---|---|

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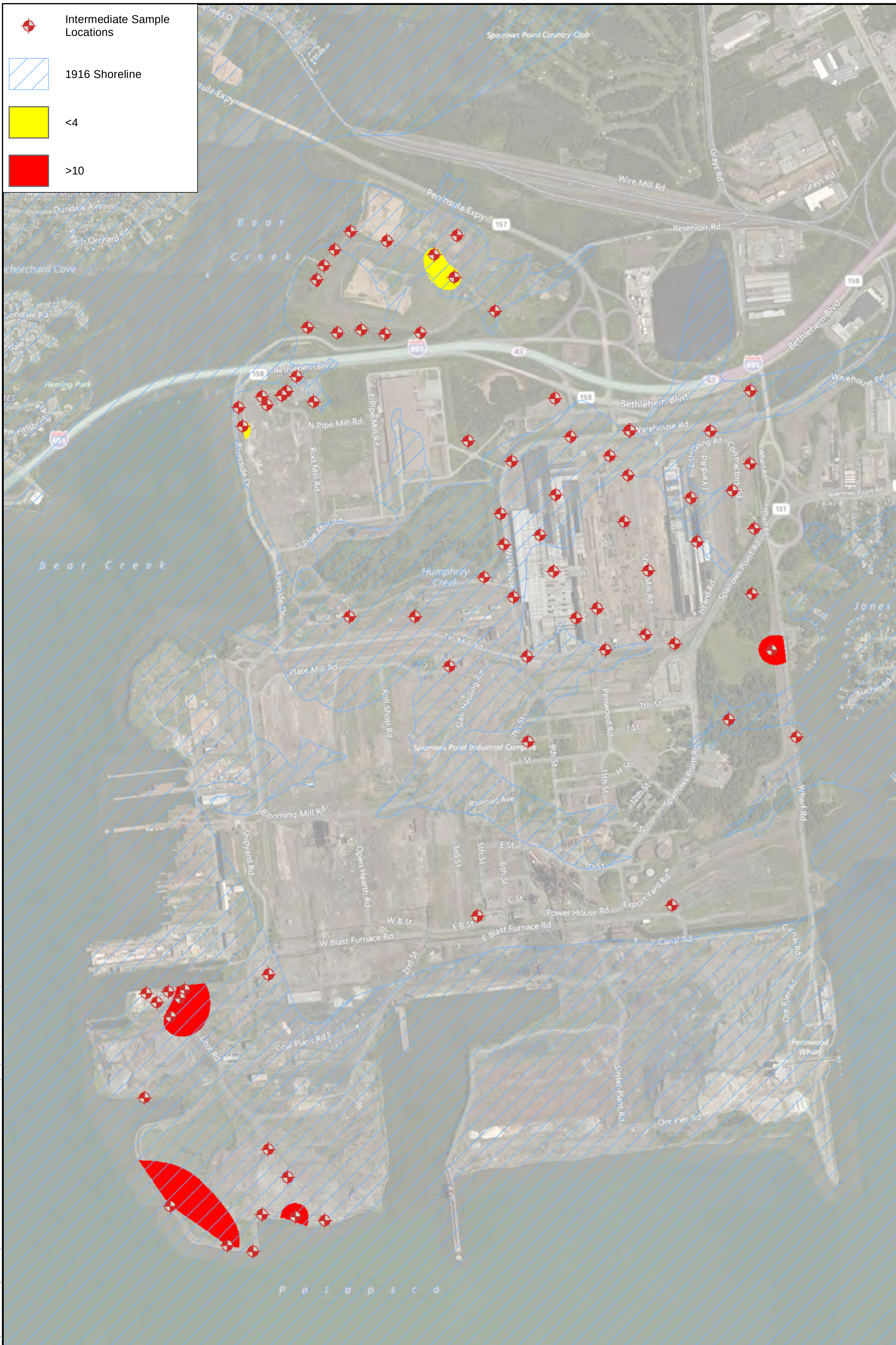


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Earth Resource Engineers and Consultants

0 500 1,000 2,000
Feet

# Site-Wide Groundwater Intermediate pH Concentrations

March 16, 2018

EnviroAnalytics Group

Tradepoint Atlantic
Baltimore County, MD

Figure
6

\\COLUMBIA\DC01\CorpData\Projects\EnviroAnalytics Group\170194M EAG Groundwater Conditions Summary Report\GIS\Site-wide GW pH and TDS.mxd