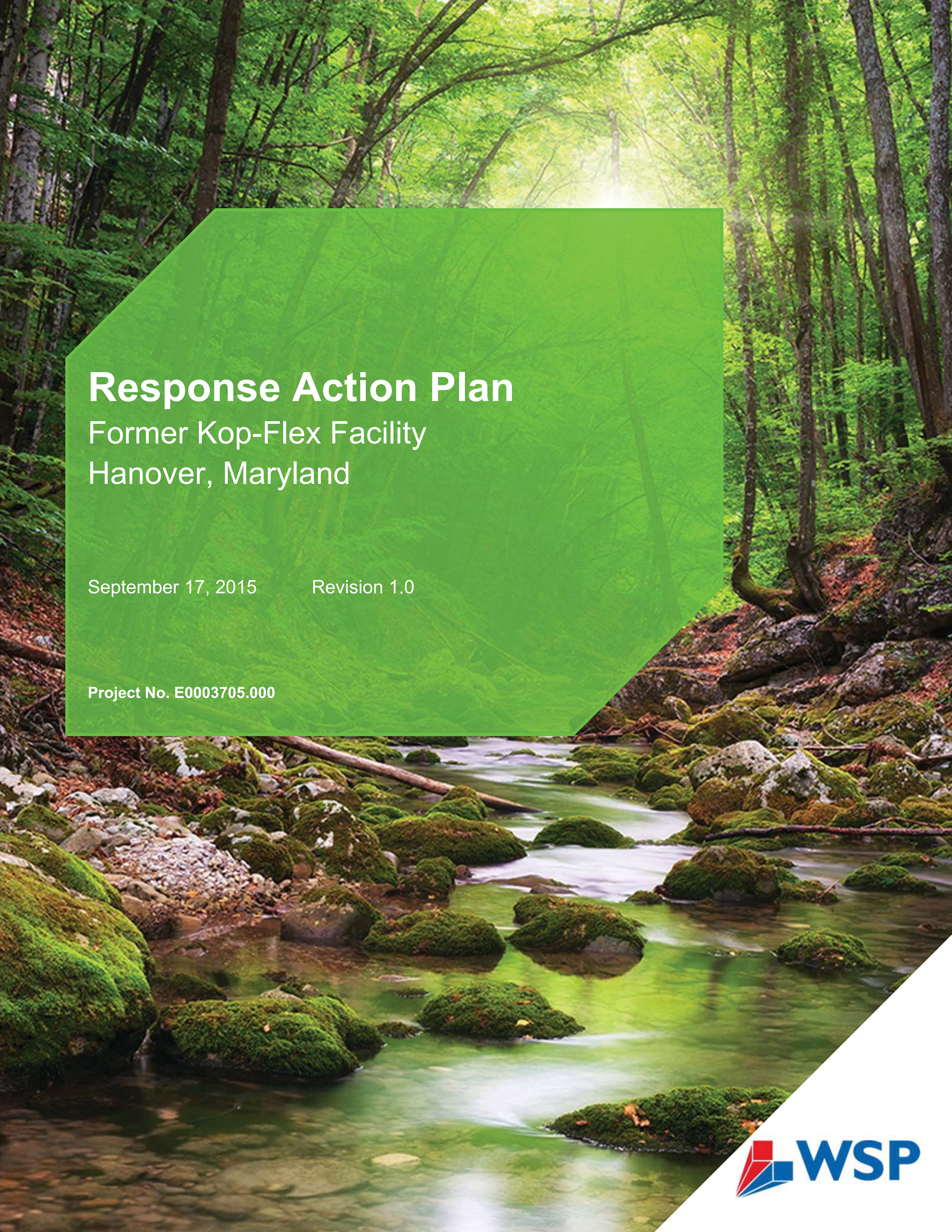

Response Action Plan

Former Kop-Flex Facility
Hanover, Maryland

September 17, 2015 Revision 1.0

Project No. E0003705.000

RESPONSE ACTION PLAN

Former Kop-Flex Facility, Hanover, Maryland

Voluntary Cleanup Program

September 17, 2015

Client

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WRITTEN AGREEMENT

EMERSUB 16 LLC
Former Kop-Flex Facility, Hanover, Maryland

If the response action plan is approved by the Maryland Department of the Environment, the participant agrees, subject to the withdrawal provisions of Section 7-512 of the Environment Article, to comply with the provisions for which it is responsible, as specified in the response action plan. Participant understands that if he fails to implement and complete the specific requirements of the approved plan and schedule, the Maryland Department of the Environment may reach an agreement with the participant to revise the schedule of completion in the approved response action plan or, if an agreement cannot be reached, the Department may withdraw approval of the plan.

Printed Name: Stephen Clarke Title: President

Signature: Date: September 14, 2015

WRITTEN AGREEMENT

TC Harmans Road LLC
Former Kop-Flex Facility, Hanover, Maryland

If the response action plan is approved by the Maryland Department of the Environment, the participant agrees, subject to the withdrawal provisions of Section 7-512 of the Environment Article, to comply with the provisions for which it is responsible, as specified in the response action plan. Participant understands that if he fails to implement and complete the specific requirements of the approved plan and schedule, the Maryland Department of the Environment may reach an agreement with the participant to revise the schedule of completion in the approved response action plan or, if an agreement cannot be reached, the Department may withdraw approval of the plan.

TC HARMANS ROAD, LLC
A Delaware limited liability company

BY: TC MidAtlantic Development V, Inc.
A Delaware limited liability company
Its sole member

By: ________________________________

Name: _David Neuman________________

Title: _Vice President_________________

Date: _September 16, 2015____________

1 Introduction

WSP USA Corp (WSP) has prepared this Response Action Plan (RAP) on behalf of EMERSUB 16 LLC (EMERSUB 16), for the former Kop-Flex, Inc. (Kop-Flex) Facility located at 7555 and 7565 Harmans Road in Hanover, Maryland. The former Kop-Flex facility is identified as Brownfield Master Inventory number MD0286 as assigned by the Land Restoration Program. This RAP pertains to the response action activities to be conducted on the former Kop-Flex property; a separate plan will be prepared and submitted to MDE to address the offsite groundwater impacts.

The RAP describes supplemental remedial actions to be conducted to address risks associated with chlorinated volatile organic compounds (VOCs) and 1,4-dioxane present in the vadose zone soil and groundwater on the former Kop-Flex property. The chlorinated VOCs of concern identified in the soil and groundwater consist primarily of 1,1,1-trichloroethane (TCA) and its degradation products (particularly 1,1-dichloroethane [DCA] and 1,1-dichloroethene [DCE]), with lower concentrations of chlorinated ethenes such as trichloroethene and *cis*-1,2-dichloroethene.

The RAP consists of the following sections:

- Section 2 – Site Overview
- Section 3 – Additional Investigation Results
- Section 4 – Aquifer Testing and Results
- Section 5 – Exposure Assessment
- Section 6 – Cleanup Criteria
- Section 7 – Remedial Alternative Selection for Soil and Groundwater
- Section 8 – Soil Response Action
- Section 9 – Groundwater Response Action
- Section 10 – Permits, Notifications, and Contingencies
- Section 11 – Project Implementation Schedule
- Section 12 – Health & Safety
- Section 13 – Waste Management
- Section 14 – Monitoring and Reporting
- Section 15 – Administrative Requirements
- Section 16 – Project Completion
- Section 17 – References
- Section 18 – Acronyms

Appendix A of this RAP includes the engineering plans to support the activities to be completed in addressing the VOC-impacted groundwater. Additional plans supporting the proposed response action activities are provided in Appendix E (Soil Management Plan) and Appendix G (Groundwater Monitoring Plan).

2 Site Background

2.1 Site Description

The former Kop-Flex site is located at 7555 and 7565 Harmans Road in Hanover, Anne Arundel County, Maryland (Figure 1). The site occupies a total area of approximately 25 acres and contains two buildings – an approximately 220,000-square-foot former manufacturing and office building and an approximately 20,000-square-foot former forge building near the eastern property boundary (Figure 2). The property is bordered to the north by a Verizon Communications maintenance facility; to the east by the Williams-Scotsman facility followed by railroad tracks; to the south by the Williams-Scotsman facility followed by Maryland State Route 100; and to the west by undeveloped land along Stony Run, a tributary of the Patapsco River, followed by Harmans Road and a residential area.

The elevation of the former Kop-Flex site varies from approximately 108 feet mean sea level (ft msl) along the drainage channel and flood plain for Stony Run to 130 ft msl in the southeast corner of the property. Although the site topography is generally flat, the main building and adjacent paved areas sit on a slight topographical rise that was reportedly created during facility construction in 1969. The ground surface gradually slopes to the north and west in the vicinity of former manufacturing and office building.

The closest surface water body is Stony Run, which crosses the northwestern portion of the site. The 100-year flood plain of Stony Run includes a portion of a paved parking area located between this stream and the manufacturing building. Stony Run flows northward and eventually discharges into the Patapsco River, which is located 7 miles from the site. In addition to this stream, several small pond areas have been identified and mapped in the vicinity of the site.

2.2 Site History

The facility was constructed on previously undeveloped land in 1969 by Koppers Company, Inc. The separate forge building was built 10 years later (1979). In 1986, an employee group purchased the company from Koppers and formed Kop-Flex, Inc. (Kop-Flex). In 1996, Emerson Electric acquired Kop-Flex.

Kop-Flex formerly manufactured flexible couplings for the mechanical power transmission industry at the site. The forge building produced precision forging of metal parts and included heat treatment and nitriding capabilities. Universal joints, gear spindles, forgings, and power transmission components were produced at the plant from 1979 to 2012. The facility also provided a repair and maintenance program for the components.

Manufacturing operations at the facility ceased in late 2012. After shutting down production activities, all equipment and machine lines were decommissioned and removed from the facility. At present, the onsite buildings are vacant except for the office building which is occupied by a small number of former plant staff. The office operations will be moved to another location in the Baltimore area in the next few months. In December 2014, Emerson transferred the property to EMERSUB 16 in preparation of selling the property to a third party for future redevelopment.

2.3 Environmental Setting

2.3.1 Geology

The former Kop-Flex site lies within the Atlantic Coastal Plain physiographic province. In Anne Arundel County, Maryland, this province is characterized by alternating layers of predominately sand and clay sediments of Cretaceous age. Based on regional hydrogeologic cross-sections for these sedimentary deposits, the inter-layered sequence of sand and clay units dips gently to both the south and east from the north part of the county. In Anne

Arundel County, the Coastal Plain deposits range in thickness from a few tens of feet along the northwestern boundary with Howard County to as much as 2,500 ft in southeastern Anne Arundel County (Vroblesky and Fleck 1991).

Evaluation of borehole lithologic data obtained from field investigations indicates the coastal plain deposits at the site comprise a complexly inter-bedded sequence of predominately coarse-grained (sand with gravel and fines) and fine-grained (silt and clay) units. Given the spatial and vertical heterogeneity typical of the Atlantic Coastal Plain deposits, the unconsolidated materials have been grouped into three gross stratigraphic units, which are generically termed “upper,” “middle,” and “lower” (Figure 3).

The Upper Stratigraphic Unit is comprised primarily of sand, with variable fines content, to gravelly sand along with occasional discontinuous silt and clay lenses of variable extent and thickness. The upper-most sandy sediments present to a depth of approximately 10 feet below ground surface (bgs) in the building area and eastern portion of the site represent fill material emplaced during construction of the facility. Extensive layers of fine-grained (silt and clay) deposits exist in the shallow subsurface in the northern portion of the site and at a depth of approximately 10 to 20 feet (bgs) in the eastern portion of the building area. This upper sandy unit appears to be thickest in the eastern portion of the former Kop-Flex facility and thins to the west.

The Upper Stratigraphic Unit is underlain by the Middle Stratigraphic Unit, which is characterized by zones of coarse-grained (sand to clayey sand) and fine-grained (silty to sandy clay to clayey to sandy silt to finely inter-laminated sand and clay) sediments exhibiting variable thickness and noticeable lateral and vertical heterogeneity. From northwest to southeast across the site, the lithologic characteristics of this unit transition from a thick (20 to 30-foot) sand interval bounded above and below by silt and clay deposits to an area of inter-bedded and inter-fingering coarse and fine-grained deposits underneath the eastern portion of the manufacturing building to a very thick (approximately 65 feet) sequence of predominately silt and clay deposits in the southern-most portion of the site. Occasional sand zones may be present as isolated lenses or layers within the fine-grained deposits, with the coarser sediments being relatively abundant beneath some areas of the building. The thick sand zone in the northern and western portion of the site occurs between the depths of approximately 30 feet to 60 feet bgs and is underlain by a layer of hard, dense silty clay to clayey silt sediments. A review of the boring logs indicates this fine-grained layer is ubiquitous within the subsurface deposits at the site.

The Lower Stratigraphic Unit is present below the Middle Stratigraphic Unit and consists primarily of sand and gravelly sand deposits with occasional discontinuous layers of inter-mixed clay and silt sediments of variable thickness. Based on correlation of the lithologic data, the top of this unit occurs at depths ranging from approximately 50 feet bgs in the northwest portion of the site to approximately 100 feet bgs near the southeastern corner of the property. Evaluation of the lithologic data indicates the gravelly sand deposits are more spatially extensive than similar lithofacies in the Upper Stratigraphic Unit.

2.3.2 Hydrogeology

The complexly stratified deposits comprising the Atlantic Coastal Plain from Virginia to New Jersey form an inter-layered sequence of aquifers and confining beds (Leahy and Martin 1993). In Anne Arundel County, the upper-most water-bearing unit is typically represented by an unconfined surficial aquifer consisting of Quarternary alluvium and terrace deposits. The thickness of the Surficial aquifer is highly variable over the area. The surficial aquifer is underlain by several confined aquifers that include the Patuxent, Lower and Upper Patapsco, and Magothy. These aquifers may be considered unconfined over their outcrop areas, although locally less permeable materials may exist at the surface. Downdip (southeast) of the outcrop and subcrop areas, the aquifers become confined, although the confining units may thin and be regionally discontinuous.

Given the textural variation of the three main stratigraphic units and their associated permeability, the predominately coarse-grained sediments comprising the upper and lower units and the thick sand interval within the middle unit represent the primary zones for groundwater flow at the site. The sand deposits present within the upper and middle units at the site constitute the shallow water-bearing zone, or Surficial aquifer, within the hydrogeologic system. The lower unit is inferred to be upper-most portion of the Lower Patapsco aquifer. Hard silt and clay deposits of the Middle Stratigraphic Unit that occur at depths ranging from approximately 45 feet in the north to 60+ feet in the south form an aquitard that hydraulically separates the Surficial and Lower Patapsco aquifers. In the southern-most portion of the site, these fine-grained, low permeability deposits are believed to represent the Patapsco Confining Unit. Overall, flow paths within these clayey deposits of the Middle Stratigraphic Unit are complex and involve predominately vertical (downward) movement of groundwater.

For the Surficial aquifer, groundwater occurs under an unconfined condition within the shallow coarse-grained deposits and the fine-grained deposits in the western portion of the site (Figure 3). Given the presence of appreciable clayey deposits in the shallow subsurface in the western portions of the site, groundwater within the sand lenses and thick sand layer within the Middle Stratigraphic Unit occurs locally under a partially, or semi-, confined condition within this portion of the surficial zone at the site. The groundwater surface is encountered at depths ranging from 15 feet to18 feet near the eastern site boundary to less than 10 feet in areas to the north and west of the building. Groundwater flow within the Surficial aquifer is in a generally west to northwest direction toward Stony Run (Figure 4). Flow within the upper-most sand units and deeper (partially confined) sand deposits provide base flow to Stony Run; however, limited data is available to unequivocally confirm the discharge contribution from the semi-confined sand zone. The consistency in the west to northwest gradient over the entire thickness of the Surficial aquifer indicates good hydraulic communication between the permeable sand intervals within this hydrogeologic unit.

Groundwater in the Lower Patapsco aquifer also occurs under semi-confined conditions, with the depth to water in wells screened in this zone ranging from approximately 30 feet in the northwest portion of the site to 45 feet bgs along the southern site boundary. Based on contouring of water level data from site monitoring wells, the direction of groundwater flow in the semi-confined Lower Patapsco aquifer is to the south-southeast (Figure 5), which is consistent with published studies of the Coastal Plain Aquifer System in Anne Arundel County, Maryland. In the southern portion of the site, the significant head differences in monitoring wells completed at depths of less than and greater than 60 feet bgs indicate that the hard silt and clay deposits in the lower portion of the Middle Stratigraphic Unit serve as a confining layer, or aquitard, between the overlying Surficial aquifer and deeper Lower Patapsco aquifer in the hydrostratigraphic sequence. However, spatial variations in the lithology and thickness of the sediments comprising the aquitard and associated sedimentary structures within the fine-grained deposits may provide mechanisms for downward leakage of groundwater to the Lower Patapsco sand deposits.

2.4 Current Site Conditions

2.4.1 Soil

2.4.1.1 Southwest Portion of Former Manufacturing Building (Area of Concern 1)

Soil sampling conducted in 1998 and early 1999 during the initial site investigation activities detected the presence of chlorinated VOCs and petroleum hydrocarbons in the unsaturated (vadose) zone beneath a former machining area in the southwest portion of the former manufacturing building (Area of Concern [AOC] 1). Evaluation of the sampling results indicated the zone of VOC-affected soil occurred at depths of greater than 7 feet bgs over the area. Based on these findings, a dual-phase extraction (DPE)/soil vapor extraction (SVE) system was installed and operated to recover chlorinated VOC mass present in the vadose zone soils. In conjunction with the remedy implementation, a former concrete well ring, which was identified as a source of VOCs to the subsurface, and the immediately surrounding soil were removed from the area. (The location of the former well ring excavation area is depicted in Figure 6).

During late 2012 and early 2013, supplemental sampling activities were performed in AOC 1 to gather updated soil quality data and assess the effectiveness of the DPE/SVE system. A total of 18 boreholes were completed over the area, with single or multiple soil samples collected for VOC analysis. The locations of soil borings completed as part of the supplemental investigation are shown in Figure 6. Although the SVE system had been successful in recovering contaminant mass, the sampling results indicate the continued presence of elevated VOC concentrations in the subsurface. Based on the sampling data, 1,4-dioxane comprised the majority of the VOC mass at depths of less than 8 to 9 feet below grade, with chlorinated VOCs becoming more prevalent in the deeper portion of the vadose zone.

Given the findings from the supplemental sampling activities, additional source area removal activities were conducted in late 2013 and early 2014 to further reduce VOC mass in the unsaturated soil and reduce the potential for constituents of concern (COCs) in soil to migrate to indoor air and groundwater. The remedial activities involved the excavation of VOC-containing soils to a depth of 15 feet below the building floor in two rectangular areas, the locations of which are provided in Figure 6. The excavated soil was segregated into stockpiles, characterized, and either transported offsite for disposal (total VOC concentrations greater than 1 milligram per kilogram [mg/kg]) or reused as backfill in the excavations (total VOC concentrations less than 1 milligram per kilogram [mg/kg]). Detailed information concerning the soil removal is provided in the Response Action Completion Report (WSP 2014).

Based on the supplemental soil sampling data, the remaining vadose zone soil beneath the building floor slab in AOC 1 contains low residual levels of site-related VOCs. Unsaturated material to a depth of less than 10 feet below grade (including the recently excavated areas) has total VOC concentrations of less than 3 mg/kg. In the unexcavated areas, the majority of the VOC mass over this depth interval appears to consist of 1,4-dioxane (see tabulated results for borings WSP-84, WSP-88, and WSP-89 in Figure 6). Slightly higher VOC levels (greater than 10 mg/kg) may locally exist in the unexcavated areas at depths below 10 feet below grade (WSP-84 location in Figure 6).

2.4.1.2 Outside Area Near East-Central Portion of Former Manufacturing Building (AOC 2)

Soil and shallow groundwater sampling activities were conducted in the area east of the former manufacturing building between 2006 and 2008, and again in 2012, to further characterize the extent of highly impacted, VOC-containing soil material in this portion of the site. Samples for VOC analysis were collected from approximately 40 borings located both inside and outside of the building (Figure 7). The soil sampling results indicated the presence of VOC-affected soil at depths of greater than 8 feet bgs in the area, and the observed presence of solvent-derived dense non-aqueous phase liquid (DNAPL) at one location immediately adjacent to the east building wall. In addition, concentrations of 1,1,1-TCA indicative of DNAPL were detected in shallow groundwater samples beginning at approximately 8 to 10 feet bgs near the building wall and extending vertically and laterally from this area to the east away from the building along the upper contact of a clay lens in the upper sand unit, and to the west.

Based on evaluation of the sampling data, source area soil removal was conducted in late 2013 to reduce VOC mass in the unsaturated and saturated soils in the area and reduce the potential for COCs to migrate in groundwater. The removal activities involved the excavation of VOC-impacted soils to depths ranging from 18 feet to 23 feet bgs in four shoring cells in the source area. The locations of the shoring cells are shown in Figure 7. The management, characterization, and final disposition of the excavated soil material were similar to the procedures described for the AOC 1 excavation activities. Flowable fill was used to backfill the cells from the terminated depth of the excavations to approximately 15-feet below ground surface to span the interval below the groundwater surface. Additional information concerning the AOC 2 soil removal is provided in the Response Action Completion Report (WSP 2014).

The remaining vadose zone soils to a depth of 8 feet bgs have non-detect to very low concentrations of 1,1,1-TCA and associated degradation compounds. Based on the sampling data, soils with 1,1,1-TCA concentrations above 10 mg/kg are locally present at depths below 8 feet in the area around the excavation cells to the east of the former manufacturing building. For these samples obtained from the deeper vadose zone (8 to 13 feet bgs), the highest 1,1,1-TCA concentration (250 mg/kg) was detected in the sample collected from 8 to 9 feet bgs at the SSI-09 location, with lower levels detected in samples from similar depths at borings SSI-05 (44 mg/kg) and WSP-68 (25 mg/kg) outside the building and WSP-07 (30 mg/kg) inside the building. Given the depth to groundwater is typically less than 13 feet in this portion of the site, the majority of the remaining VOC mass appears to be present in the upper-most portion of the saturated zone (Figure 7).

2.4.2 Groundwater

2.4.2.1 Overview

The initial activities related to understanding the onsite groundwater conditions were conducted as part of the Phase II assessment (ESC 1999a). These investigation activities included the collection and evaluation of data to characterize the subsurface geology, and the installation and sampling of 13 Surficial aquifer monitoring wells (MW-1 through MW-12 and MW-14) on the property (Figure 2). The sample results indicated the presence of site-related COCs, consisting primarily of chlorinated VOCs and petroleum hydrocarbon constituents, in the shallow groundwater system. COC concentrations above the comparative criteria were detected in groundwater samples collected from areas to the east and immediately west of the former manufacturing building.

In addition, limited sampling of extracted groundwater was performed in conjunction with the pilot testing of groundwater remedial technologies in the VOC-impacted areas (ESC 2001a and 2001b). Analytical results for the samples from both tests indicated high total VOC levels in the Surficial Aquifer, with maximum concentrations of greater than 150 milligrams per liter (mg/l).

Based on the pilot test results, a dual phase extraction (DPE)/soil vapor extraction (SVE)system was implemented inside the southwestern portion of the former manufacturing building (AOC 1) and a network of Unterdruck-Verdampfer-Brunnen (UVB), or “vacuum vaporized”, wells were installed to address the VOC-impacted Surficial aquifer east of the manufacturing building (AOC 2). As part of the remedial activities, a groundwater monitoring program was implemented to evaluate trends in VOC concentrations in the Surficial aquifer. The monitoring activities included semi-annual sampling of the 13 Surficial aquifer wells at the site. Table 1 summarizes the historical VOC data obtained during the semi-annual groundwater sampling events from 2009 through 2014.

Several supplemental investigation phases were completed between 2006 and 2013 to further evaluate the horizontal and vertical extent VOCs in the aquifer system (WSP 2013b). These investigations primarily focused on the area east of the main building (AOC 2) and included the following activities related to onsite groundwater:

- groundwater profiling at 14 locations in AOC 2 (2006)
- installation and sampling of five intermediate-depth Surficial aquifer monitoring wells (MW-15, MW-16, MW-17, MW-18 and MW-20) and eight Lower Patapsco aquifer wells (MW-1D, MW-2D, MW-16D, MW-17D, MW-19, MW-21D, MW-22D and MW-23D) (2010 – 2012)[1]
- depth-discrete groundwater sampling to further characterize the extent of VOCs in the Surficial aquifer in AOC 1 and AOC 2, and installation and sampling of one deep monitoring well (MW-26D) in AOC 1 (2012 – 2013)
- installation of an upgradient monitoring well (MW-27D) in the Lower Patapsco aquifer (2013)

The locations of the monitoring wells installed as part of the supplemental investigations are indicated in Figure 2. Groundwater samples collected from the Surficial aquifer in AOC 1 and AOC 2, and Lower Patapsco aquifer in the southern and eastern portions of the site were found to contain elevated concentrations of 1,1,1- TCA, the degradation products 1,1-DCA and 1,1-DCE, and 1,4-dioxane. All new monitoring wells were incorporated into the site-wide, semi-annual groundwater monitoring program to gather additional water quality data for the aquifer system.

During the 2013 response action activities, Emulsified Zero Valent Iron (EZVI) was injected into the shallow groundwater zone in AOC 2 in order to further reduce hot spot VOC concentrations in the saturated soil. The EZVI creates a treatment zone in the shallow groundwater that has the ability to reduce VOCs for an extended period of time via *in situ* abiotic dechlorination. This work is also summarized in the Response Action Completion Report (WSP 2014).

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[1] In addition to the onsite wells, one deep monitoring well (MW-24D) was installed on the adjacent Williams-Scotsman property immediately south of the site.

As discussed in Section 3.3, additional groundwater profiling is planned for the Surficial and Lower Patapsco aquifers to further define the extent of VOC-impacted groundwater to the east of the former Kop-Flex facility in the shallow groundwater and to the north in the deep groundwater.

2.4.2.2 Surficial Aquifer

Discussion of the groundwater quality is based on data from the December 2014 monitoring event, which involved the sampling of 21 shallow (20 to 40 feet bgs) and intermediate (40 to 60 feet bgs) depth wells. The locations of the groundwater monitoring wells are shown on Figure 2. The wells range in depth from 22 feet bgs to 60 feet bgs.

For the Surficial aquifer, the VOCs of concern are 1,1,1-TCA and its degradation products (e.g., 1,1-DCE and 1,1-DCA), chlorinated ethenes such as trichloroethene and tetrachloroethene, and 1,4-dioxane. The highest VOC levels in shallow groundwater are found in the identified source areas underneath and east of the former manufacturing building, and decrease in the direction of groundwater flow. VOC impacts in shallow groundwater extend from the vicinity of wells MW-02, MW-11, MW-12 and MW-16, which are located to the east of the former manufacturing building, to the area west of the building in the vicinity of MW-38. Figures 8 depicts the inferred VOC distribution (including 1,4-dioxane) in the upper portion of the Surficial aquifer at the site.

Well MW-01 is the only Surficial aquifer monitoring point that is situated upgradient of the source areas and provides background water quality data for this hydrogeologic unit. No site related VOCs have been detected in samples from MW-01. VOC concentrations detected in wells near the eastern property boundary (MW-08 and MW-20) are substantially lower than concentrations in wells located in close proximity to the source area to the immediate east of the former manufacturing building (MW-02, MW-11, MW-12, and MW16).

VOCs associated with the source area immediately east of the former manufacturing building have migrated west (downgradient) and commingled with VOCs associated with the source area below the southwest portion of the building. In the area west of the former manufacturing building, the highest VOC concentrations are found in samples collected from the shallow wells screened in the upper, predominately clayey deposits, with trace to non-detect levels in samples from intermediate-depth wells screened in the underlying sand unit (MW-14, MW-18 and MW-39) (Figures 8 and 9). Typically non-detect levels of site-related VOCs have been found in samples from shallows wells MW-03 and MW-07 northwest of the manufacturing building. Based on evaluation of the sampling data, no site-related VOCs appear to be migrating offsite at levels of concern in the shallow portion of the groundwater system.

2.4.2.3 Lower Patapsco Aquifer

The discussion on groundwater quality for the semi-confined Lower Patapsco Unit is based on sampling data from the 10 deep onsite wells and offsite well MW-24D from the December 2014 monitoring event. The locations of the groundwater monitoring wells are shown on Figure 2. These wells generally range in depth between 90 feet bgs and 130 feet bgs.

The VOCs detected in samples from wells installed in the Lower Patapsco aquifer are consistent with those identified for the shallow water-bearing zone: 1,1,1-TCA and its degradation products, chlorinated ethenes, and 1,4-dioxane. An iso-concentration map showing the inferred total VOC distribution is provided in Figure 10. Overall, VOC impacts in the deep groundwater extend from the identified source area to the east of the manufacturing building to the off-property areas to the south-southeast of the former Kop-Flex facility. As indicated in the VOC plume map, the highest VOC concentrations occur in the vicinity of on-property well MW-17D and off-property well MW-24D, which are located immediately downgradient of the source area. Elevated VOC concentrations were also detected in the samples from well MW-1D along the southern property boundary.

Wells MW-19, MW-23D, and MW-27D are located upgradient of the VOC source areas at the site. Trace to non-detect concentrations of VOCs were detected in samples collected from MW-19 and MW-27D. Well MW-23D, which is located approximately 120 feet north of the former manufacturing building, contained low levels of site-related VOCs, primarily 1,4-dioxane and 1,1-DCE.

2.5 Future Land Use

Although the past land use has been industrial, the property will be sold and redeveloped for commercial use. In December 2014, EMERSUB 16 LLC completed a purchase and sale agreement with TC Harmans Road, LLC, who will redevelop the property and construct commercial warehouses. An overlay of the proposed development plan for the property is shown in Figure 2. The planned commercial use of the property was indicated in the new VCP application EMERSUB 16 submitted to MDE on January 30, 2015, and the TC Harmans Road, LLC VCP application, received by MDE on January 20, 2015. Both VCP applications were approved for participation on March 4, 2015.

2.6 Response Actions

2.6.1 Soil

Based on the previous investigation and remediation activities, low concentrations of VOCs (primarily 1,4-dioxane) remain in the shallow soil (less than 10 feet bgs) underneath the southwest portion of the former manufacturing building (AOC 1) (see Figure 2). In addition, soil gas may contain VOCs derived from the partitioning of residual contaminant mass in the unsaturated soil and volatilization of constituents from the groundwater surface. The results of the updated site-specific risk assessment demonstrate the soil and soil vapor conditions do not pose any unacceptable human health risk to facility workers, child or youth intermittent visitors, or construction workers under the current site conditions (WSP 2015). Under the future land use scenario, the calculated risks to workers or visitors associated with COC-containing soil would also be below the target risk values; however, the potential may exist for future risks associated with vapor intrusion into new building structures.

The site response actions for soil will include the implementation of land use and engineering controls to prevent future exposure to soil containing VOCs and other COCs that remain at the site. Institutional controls will consist of filing a land deed notice restricting the property to non-residential use, and developing and implementing soil management procedures for any intrusive activities performed within the known VOC-affected area. Engineering controls will involve the incorporation of a vapor barrier and vapor collection system in future buildings constructed at the site to prevent VOC-containing vapors from entering the structures. Procedures (including recordkeeping) for the inspection and repair/maintenance of the vapor mitigation measures or other engineering controls will be included in the Site Management Plan to be prepared as part of the soil response action activities.

2.6.2 Groundwater

Information on the groundwater quality at the former Kop-Flex facility has been continually gathered from the sampling of onsite monitoring wells. Evaluation of the historical monitoring data indicates concentrations of chlorinated VOCs and 1,4-dioxane above the applicable groundwater standards in the Surficial aquifer below and to the east of the former manufacturing building. The affected area forms a slightly elongate plume of VOC-containing groundwater with the long axis oriented in a generally east-west direction consistent with the overall flow paths in this hydrogeologic unit. Groundwater samples collected from wells along the western (*i.e.*, hydraulically downgradient) property portion of the site show that the surficial VOC plume does not extend to the property boundary. (Additional groundwater investigations to further assess the eastern extent of the VOC-impacted groundwater in the surficial zone are described in Section 3.3.) VOC concentrations above the comparative groundwater standards have also been detected in samples from the deeper groundwater zone, which is interpreted to represent the semi-confined portion of the Lower Patapsco aquifer in the Coastal Plain Aquifer System. In this hydrogeologic unit, VOC impacts occur primarily in the southern portion of the site and extends southward off the Kop-Flex property. (Field investigations to further characterize the groundwater quality in the semi-confined portion of the aquifer north of the site are described in Section 3.3.)

Hydraulic containment via the pumping of VOC-containing groundwater has been selected as the response action to address the impacted aquifers at the site. An extraction network of shallow pumping wells screened within the Surficial aquifer and deep wells completed in the Lower Patapsco aquifer will serve to contain the VOC-affected groundwater to the site. Surficial aquifer extraction wells will be located in the western portion of the site near the downgradient limit of the shallow VOC plume, and the extraction wells to control VOC migration in the Lower Patapsco aquifer will be located along the downgradient (south) property boundary. The combined flow from the extraction wells will be treated to remove the site-related contaminants in accordance and the treated effluent will be discharged to Stony Run pursuant to the approved discharge permit. Preliminary (conceptual) engineering drawings of the proposed hydraulic containment systems are provided in Appendix A. Groundwater monitoring activities to be performed during system operation are specified in the Groundwater Monitoring Plan accompanying the RAP.

Potable water at the former Kop-Flex site is obtained from the municipal water system; however, there is no restriction on the use of groundwater at the site. Therefore, an environmental covenant will be enacted to prohibit the use of groundwater at the site. The groundwater use restriction will be recorded in the Anne Arundel County land records office for the property. The Environmental Covenant will be prepared and recorded following the construction of the new warehouse buildings and documented in the Groundwater Construction Completion and Implementation Report to be submitted to MDE.

3 Additional Site Investigations

3.1 Soil Sampling for Proposed Development

In September 2014, thirteen direct-push soil borings were completed to depths of 6 feet bgs in a future loading dock area between two proposed warehouse buildings. Nine boring were installed in the former manufacturing building, one was installed to the west of the building, and three were installed to the east of the building. Soil samples were collected from ten of the thirteen locations and analyzed for VOCs, polycyclic aromatic hydrocarbons, gasoline and diesel range petroleum hydrocarbons, polychlorinated biphenyls, and metals using USEPA-approved test methods. The locations of the shallow soil borings are shown in Figure 11.

Table 2 summarizes the laboratory results for the samples submitted for chemical analysis. The samples contained non-detectable or trace concentrations of site-related VOCs and PAHs. Metal concentrations, except for arsenic in two samples, were below MDE Residential Soil Cleanup Standards. Although two samples had arsenic above the MDE Residential Soil Cleanup Standard, the concentrations were determined to be below the typical MDE bioavailability standard.

3.2 General Hydrogeochemical Parameters

To assess potential hydrogeochemical factors that could influence the treatment process, groundwater samples were collected from selected shallow aquifer wells (MW-05, MW-18, MW-38, and TW-1) in October 2014 and selected deep aquifer wells (MW-1D, MW-2D, MW-16D, MW-17D, MW-21D, and MW-26D) in December 2013. The samples collected from both the shallow and deep wells were analyzed for selected metals (aluminum, copper, iron, lead, manganese, nickel, and zinc) and total hardness (as calcium carbonate) using USEPA-approved test methods. In addition, groundwater samples from Surficial aquifer wells were analyzed for total petroleum hydrocarbons, and samples from the confined Lower Patapsco aquifer wells were tested for total alkalinity. The analytical results for the samples collected from the shallow aquifer and deep aquifer wells are summarized in Tables 3 and 4, respectively. The certified analytical laboratory report for the samples is provided in Appendix B.

3.3 Groundwater Quality Profiling

3.3.1 Overview

As shown in the iso-concentration maps cited in Section 2.4.2, the upgradient extent of VOC-affected groundwater has not been fully delineated in both the Surficial and Lower Patapsco aquifers at the site. Given this data gap, additional field investigations will be conducted to further define the extent of VOC-impacted groundwater to the east of the former Kop-Flex facility in the shallow groundwater and to the north in the deep groundwater. These investigation activities will involve the drilling and groundwater profiling of one shallow borehole (WSP-95) on the adjoining Williams Scotsman, Inc. property and a deep borehole (WSP-96) on the neighboring Verizon property. The proposed locations for the shallow and deep sample boreholes are shown on Figures 8 and 10, respectively. The field and analytical data will be evaluated to determine the appropriate locations for the future installation of permanent groundwater monitoring wells.

3.3.2 Borehole Installation and Depth-Discrete Groundwater Sampling

Each borehole will be advanced using the roto-sonic drilling method, with the shallow borehole (WSP-95) completed to a depth of approximately 60 feet bgs and the deep borehole (WSP-96) extended to approximately 120 feet bgs. The actual borehole depths will be determined in the field based on the lithologic data and the detection of chlorinated VOCs during the field screening of depth-discrete groundwater samples. During borehole installation, continuous, 5-foot-long (WSP-95) and 10-foot long (WSP-96) cores of the unconsolidated geologic materials will be obtained using the drilling method's coring system. The recovered material from each core run will be screened for VOCs at approximately 5-foot intervals using a soil head space procedure and photoionization detector (PID) fitted with an 11.7 electron volt (eV) lamp. The screening process will be compliant with WSP Standard Operating Procedure (SOP) #9. (Copies of applicable field SOPs for the investigation are included in Appendix C.) Field screening results and descriptive information will be recorded by a WSP Geologist in a bound field notebook.

For the shallow boring (WSP-95), groundwater samples will be collected from the predominately sand deposits using a depth-discrete sampling system. Groundwater samples will be collected at approximately 10-foot intervals from a few feet below the water table (approximately 20 feet bgs) to the borehole termination depth, although the vertical interval between successive sampling points will be dictated by the nature and heterogeneity of the unconsolidated deposits. After setting the sampler at the desired sample depth, groundwater will be continuously purged at a low pumping rate to ensure that water representative of aquifer conditions is being collected from the depth interval. During purging, field hydrogeochemical parameters, including temperature, pH, and specific conductance, will be monitored at regular (5-minute) intervals, and the measurements recorded in the field notebook. Once the field parameters have stabilized, groundwater samples will be collected for 1,1-DCE field screening using colorimetric tubes and the Color-Tec procedure, and laboratory analysis. At the deep boring location (WSP-96), the borehole will be advanced through the surficial water-bearing zone and underlying aquitard before commencing the sampling activities. Depth-discrete groundwater samples will be collected at approximately 10-foot intervals beginning at a depth of 5-10 feet below the bottom of the confining unit until termination of the borehole. Each groundwater sample will be collected following stabilization of the field hydrogeochemical parameters during purging and field screened for 1,1-DCE using the Color-Tec procedure. Additionally, a sample will be collected for submittal to an offsite laboratory for chemical analysis. All purge water generated during the sampling activities will be contained in Department of Transportation (DOT)-compliant 55-gallon steel drums and managed in accordance with the procedures described in WSP SOP #5. After completing the sampling activities at a given location, the borehole will be backfilled to a few inches below the paved surface with cement-bentonite grout and then capped with a layer of concrete to match the existing grade.

Each depth-discrete groundwater sample will be submitted to the Phase Separation Science, Inc. laboratory in Baltimore, Maryland and analyzed for VOC and 1,4-dioxane. The groundwater samples for VOC analysis will be analyzed using U.S. EPA SW-846 Test Method 8260B. Samples for 1,4-dioxane analysis will be analyzed using modified U.S. EPA Method 8260B with Selective Ion Monitoring (SIM). Proper quality assurance procedures, including the collection of field quality control (QC) samples, will be implemented in accordance with WSP SOP #4.

3.3.3 Surveying of Sample Locations

A surveyor licensed in the State of Maryland will survey the locations and elevations of the sample boreholes completed during the field investigation activities. The elevation of the ground surface will be surveyed to the nearest 0.01 foot. The horizontal location of the borings will also be determined to the nearest 0.1 foot. Horizontal and vertical data for each location will reference the Maryland State Plane coordinates and the NAVD1988 datum, respectively. The locations will be plotted on a scaled map showing both the former Kop-Flex facility and the surrounding area.

3.3.4 Management of Investigation Derived Media

In addition to the sampler purge water, the following investigation-derived media (IDM) will also be generated during the field investigation activities:

- drill cuttings
- solid-containing drilling water

- decontamination water
- miscellaneous solid materials that come in contact with potentially contaminated soil or groundwater (e.g., personal protective equipment, plastic, tubing, etc.)

All IDM listed will be containerized in DOT-compliant 55-gallon steel drums. The drummed materials will be labeled as “non-hazardous pending analysis”, inventoried and moved to a paved, covered staging area on the property.

During completion of the field activities, composite samples of the solid and liquid IDM will be collected and analyzed to determine the appropriate method for the management of these materials. All IDM will be managed in accordance with state and federal regulations.

4 Aquifer Testing and Results

4.1 Aquifer Testing

4.1.1 Test Design and Performance

Aquifer tests were performed on the Surficial and Lower Patapsco aquifers at the site between April and May 2014. Before initiating any test activities, additional wells and piezometers necessary for conducting the field tests were installed on the former Kop-Flex property. For the Surficial aquifer, one 4-inch diameter extraction well (TW-1), one shallow monitoring well (MW-38), and three deeper monitoring wells and piezometers (MW-39, OW-1, and OW-2) were installed in early April 2014. The extraction well was screened within the predominately sand deposits present in the lower portion of the Surficial aquifer (see section A-A' in Figure 3). A deep, double-cased extraction well (TW-2) was installed along the southern property boundary for conducting the pumping test in the semi-confined portion of the Lower Patapsco aquifer. The locations of the wells and piezometers constructed as part of the test activities are shown in Figure 2. Detailed information on the drilling and installation these additional wells and piezometers (including boring logs) is provided in Appendix D.

The field testing activities were performed in accordance with the Scope of Work for Aquifer Testing, dated March 12, 2014. Aquifer testing was first conducted on the Surficial aquifer in the area immediately west of the former manufacturing building and then on the Lower Patapsco Aquifer in the southern portion of the site. For each test, field data were gathered during (1) pre-test (background) water level monitoring, (2) step-drawdown test of the groundwater extraction well, and (3) 72-hour constant discharge pumping test. The constant discharge test was designed to record water level changes in the aquifer during and following the cessation of groundwater pumping. The groundwater discharge from both tests was treated and eventually discharged to Stony Run at Outfall 001 in accordance with the facility's National Pollutant Discharge Elimination System (NPDES) Permit MD0069094 and State Discharge Permit No. 07-DP-3442. Water level readings over the duration of the constant discharge test were used to calculate the following aquifer hydraulic parameters: hydraulic conductivity (K), transmissivity (T), storativity (S), and leakage.

4.1.2 Test Results

The following section summarizes the results for the aquifer tests conducted for both the Surficial and Lower Patapsco aquifers at the site. Additional discussion of the test procedures, and data reduction and analysis methods is provided in Appendix D.

4.1.2.1 Surficial Aquifer

For the Surficial aquifer constant discharge test, a relatively large area of hydraulic influence was created within both the sand unit screened by pumping well TW-1 and the overlying, predominately finer grained silt and clay deposits at the selected pumping rate of 11 gallons per minute (gpm). The noticeable water level displacement in the shallow observation wells (MW-05 and MW-39) indicated good hydraulic communication within the unconsolidated deposits, with and appreciable vertical flow of water from the shallow clayey unit to the deeper sand unit. Based on the specific capacity (yield per unit of well drawdown) of the pumping well and available drawdown, the long term sustainable yield for a well screened in the sand deposits of the Surficial aquifer is approximately 7 gpm. If the well screen extends into a portion of the overlying silt and clay deposits, then maintaining the groundwater level above the screened interval would result in a smaller maximum available drawdown and corresponding decrease in the long term sustainable yield. For example, an increase in the well screen from 30 feet to 35 feet would cause a reduction in the long term well yield to approximately 4 gpm.

Table 5 summarizes the calculated hydraulic parameters derived from the corrected drawdown and recovery data collected during the constant discharge rate pumping test. Estimated values K and T values for the sand deposits comprising the Surficial aquifer are consistent with typical published values for these types of unconsolidated materials. The K values for the sandy aquifer materials in the area west of the former manufacturing building ranged from 5.2 feet per day (ft/day) to 15.6 ft/day, with a geometric mean of 9.21 ft/day. Based on a leaky confined flow model, the storativity values for the sand deposits ranged from 7×10^{-4} to 8×10^{-4}.

4.1.2.2 Lower Patapsco Aquifer

A large area of hydraulic influence was also created within the semi-confined Lower Patapsco aquifer during the constant discharge test, with the resultant cone of depression around the pumping well forming a slightly ellipsoidal area elongated in a direction perpendicular to flow. Plots of the corrected drawdown *vs.* time data suggest a leaky or semi-confined condition for the aquifer, although an accurate evaluation of this leakage is difficult due to the abnormal hydrologic conditions during the test. The aquifer response during groundwater withdrawal appears to support the existing conceptual hydrogeologic model of the site, which indicated some very limited hydraulic communication across the confining layer that separates the aquifers at a depth of approximately 60 feet bgs. Based on the observed drawdown during both the step and constant rate tests, an extraction well which is designed similar to TW-2 would be able to achieve long term sustainable yields approaching 50 gpm.

Table 6 summarizes the calculated hydraulic parameters derived from the corrected drawdown and recovery data collected during the constant discharge rate pumping test. Based on hydrogeologic information gathered during the installation of the three MW-25 series offsite monitoring wells, the inferred thickness of the confined Lower Patapsco aquifer in the site vicinity is estimated to be 80 feet. Aquifer transmissivities obtained from the data analysis show a limited range of values, ranging from a minimum of 1,170 square feet per day (ft^2/day) to a maximum of 1,620 ft^2/day. The geometric mean of the transmissivity values obtained from the test is 1,410 ft^2/day. Based on an inferred thickness for the Lower Patapsco aquifer of 80 feet, the calculated hydraulic conductivity values for the aquifer materials in the area around TW-2 varied from 14.6 ft/day to 20.3 ft/day, with a geometric mean K of 17.7 ft/day. The estimated geometric mean T and K values are similar with data cited in other hydrogeologic reports for the Coastal Plain deposits in central Maryland.

4.2 Predictive Flow Simulations for Groundwater Containment

4.2.1 Technical Approach

The proposed response action will involve the installation of a groundwater collection and treatment system for hydraulic containment of the dissolved VOC plumes in the Surficial and Lower Patapsco aquifers. The Surficial aquifer wells will be located in the area west (downgradient) of the former manufacturing building in order to prevent any potential transport of VOCs above the applicable groundwater quality criteria to the Stony Run drainage area. For the deeper, semi-confined Lower Patapsco aquifer, groundwater withdrawal will be focused along the southern property boundary to minimize further VOC migration to the south.

The technical approach for determining the layout of the groundwater extraction well networks for each aquifer consisted of a two-step process. The initial phase, which was discussed above, involved the completion of pumping tests in each aquifer to evaluate the general effectiveness of groundwater withdrawal from wells as a hydraulic control measure for the VOC plumes. The test results and other hydrogeologic data gathered during previous field investigations were then used to predict the water level drawdown and associated flow pathways in response to remedial pumping in each aquifer using a two-dimensional, analytical steady-state groundwater flow model. Evaluation of the predictive flow simulations was conducted to determine the locations and pumping rates for the groundwater extraction wells to achieve plume containment at the site.

The WinFlow analytical groundwater flow modeling tool was used to simulate groundwater movement within the different units at the site. The WinFlow Solver is part of the non-proprietary computer program AquiferWin32 developed by Environmental Simulations Incorporated (ESI) that simulates two-dimensional steady state and transient groundwater flow. The steady state flow module, which was utilized for determining the extraction well lay-out, simulates flow in a horizontal plane using the analytical functions developed by Lindeburg (1989), and the principle of superposition to evaluate the effects of multiple functions (e.g., pumping wells, recharge, etc.) on the uniform flow field. Both unconfined and confined aquifers can be simulated using the steady state flow module. Homogeneous aquifer hydraulic properties were designated over the model areas, and a constant-head condition specified along the upgradient boundaries of the model area based on the local hydrogeologic data. No sources of water to the groundwater system (e.g., areal recharge to the water table via infiltration of precipitation) were included in the analytical functions. For the Surficial aquifer flow simulations, Stony Run was modeled as a constant-head line sink, with the surface water elevation approximately 2 feet below the surrounding ground surface elevation. Reverse particle-tracking simulations were performed to trace the horizontal movement of groundwater in the aquifer and simulate the area of groundwater capture for each remedial pumping scenario.

A discussion of the flow simulations used to select the locations and pumping rates for the groundwater extraction well systems is provided in the following sections.

4.2.2 Surficial Aquifer

Model input parameters are based on hydrogeologic data obtained during previous field investigations at the site and are provided in Table 7. Given the good hydraulic communication between the upper clayey and lower sand units, a uniform equivalent horizontal hydraulic conductivity was calculated for the aquifer based on the borehole lithologic data and parameter estimates from the recent aquifer test and slug tests on dual-phase extraction wells conducted in 2002.

Extraction wells were defined within the inferred extent of the VOC plume in the western portion of the site to select potential spacing and pumping rates for the proposed hydraulic containment system. Based on the inferred width of impacted groundwater in the building area, the Surficial aquifer hydraulic containment system consists of three extraction wells (RW-1S, RW-2S, and RW-3S) located immediately west of the former manufacturing building (Figure 12). Extraction well locations were adjusted slightly during the model runs based on evaluation of the total pumping rate for the well system and percentage of the plume cross-sectional area captured under simulated steady-state flow conditions. The simulated groundwater extraction wells were assigned a diameter of 4 inches, which corresponds to the diameter of the test well used in the 2014 aquifer test. Given the presence of VOCs in both the clayey and sandy units, the extraction wells were modeled with screened intervals within the lower 5 feet of the upper fine-grained layer and fully penetrating the lower coarse-grained deposits. Table 8 summarizes the extraction well construction information input into the groundwater flow model for the remedial pumping scenarios. The extraction well construction information was not varied during the remedial pumping flow simulations.

Groundwater withdrawal was represented as a single stress period with a constant extraction rate at each well. The range of potential pumping rates was based on the long term sustainable well yield determined from the recent aquifer test described in Section 4.1. Withdrawal rates for the stress period were adjusted between model runs by trial and error in light of the presumed range in sustainable well yields for this aquifer. The final simulated pumping rate for each extraction well was determined to be 3 gpm. For the final pumping scenario, the total daily groundwater withdrawal from the Surficial aquifer extraction wells is 12,960 gallons.

The map depicting the simulated groundwater surface, or water table, during remedial pumping of the Surficial aquifer extraction wells is shown in Figure 12. The simulated area of groundwater in-flow to the extraction wells is also shown in Figure 12 for this water-bearing zone. Changes in groundwater levels attributed to remedial pumping appear to be relatively small over the area of interest, with drawdown focused in the vicinity of the extraction wells. As indicated by the groundwater surface map, the simulated particle traces also show the convergence of groundwater flow caused by sustained withdrawals from extraction wells clustered in the area west of the main building. The predicted zone of extraction well in-flow indicates good capture of VOC-impacted groundwater underneath and a short distance west of the former manufacturing building (Figure 12). Comparison of the extraction well in-flow area with the inferred VOC distribution in the aquifer indicates the affected groundwater upgradient of the well system is sufficiently captured by the hydraulic containment system operating at the modeled conditions.

4.2.3 Lower Patapsco Aquifer

As with the remedial pumping flow simulations for the shallow groundwater zone, model input parameters for the semi-confined Lower Patapsco aquifer are based on hydrogeologic data obtained during previous site investigations and are listed in Table 9. Extraction wells were defined within the inferred extent of the VOC plume on the south portion of the property to select potential spacing and pumping rates for the proposed hydraulic containment system. Based on the inferred extent of impacted groundwater in this portion of the aquifer system, two deep extraction wells (RW-1D and RW-2D) were selected in the model area of interest at the locations shown in Figure 13. Given the probable range in withdrawal rates from this aquifer, the simulated groundwater extraction wells were assigned a diameter of 6 inches. Since the profiling data from previous onsite investigations indicates VOC-impacted groundwater is limited to approximately the upper 40-50 feet of the aquifer thickness, extraction wells could be similar in design to test well TW-2 and only partially penetrate the Lower Patapscoaquifer. However, the WinFlow modeling program used to determine the well lay-out only allows for the extraction of groundwater from fully penetrating wells. For this flow simulation, the fully-penetrating extraction wells were designed with 50 feet of well screen to simulate the withdrawal of groundwater from the aquifer. Even though the modeled wells may not coincide with the proposed extraction well construction, the predicted well pumping rates should be conservative and more than sufficient to produce the necessary hydraulic containment effect in the aquifer. Table 8 summarizes the extraction well construction information input into the flow model program. The extraction well construction was not varied during the remedial pumping flow simulations.

Extraction rates were adjusted to maximize the capture area overlapping the cross-sectional area of the VOC plume, while minimizing the total groundwater withdrawal rate. Groundwater withdrawal was represented as a single stress period with a constant pumping rate for each well. The upper bound of potential withdrawal rates was based on the long term sustainable well yield determined from the spring 2014 aquifer test. Pumping rates for the stress period were adjusted between model runs by trial and error in light of the presumed range in sustainable well yields for the aquifer. The final simulated pumping rate for the both extraction wells was 35 gpm, with a total groundwater withdrawal from the aquifer of 100,800 gallons per day (gpd).

A site plan depicting the simulated potentiometric surface and area of groundwater in-flow to the extraction wells during remedial pumping is presented in Figure 13. The configuration of the head contours indicates a few feet of drawdown in the area around the extraction wells and the southern property boundary. The simulated particle traces depict the convergence of groundwater flow caused by the sustained withdrawals from the two extraction wells. The predicted zone of extraction well in-flow shows adequate containment of VOC-impacted groundwater in the confined Lower Patapsco aquifer on the former Kop-Flex property (Figure 13). Comparison of the extraction well in-flow area with the inferred VOC distribution in the aquifer indicates the affected groundwater upgradient of the well system is sufficiently captured by the hydraulic containment system operating at the modeled conditions. It should be noted the VOC distribution in the Lower Patapsco aquifer was determined from geostatistical analysis of available groundwater sampling data. Given the spatial distribution of the monitoring points, there is some degree of uncertainty with respect to the exact location of the plume ‘boundary’ in this area, particularly east of the former Kop-Flex property. This uncertainty was taken in consideration when evaluating remedial pumping scenarios to ensure the operation of the proposed extraction well system achieves the desired response action objectives.

5 Exposure Assessment

Potential exposure pathways and the resulting risks were evaluated in detail in a recent site-specific risk assessment (SSRA; WSP 2015). A summary of the potential exposures is discussed below.

5.1 Site Use

The former Kop-Flex facility was used for manufacturing from 1969 to 2012, when the plant closed. A small number of office employees remain on the property; these office functions will be relocated in the next several months.

Current plans involve the redevelopment of the property as a commercial warehouse facility. Two distribution warehouses are planned, with one on the north portion of the site and a second on the south portion and a loading dock area separating the buildings. The future use of the site will correspond to Tier 2B (Commercial-Restricted) under the Maryland Voluntary Cleanup Program (VCP).

5.2 Media of Concern

5.2.1 Soil

Historical manufacturing activities and storage of hazardous materials and wastes resulted in releases of COCs (primarily VOCs) to the ground surface or to subsurface soils. Previous remediation activities, including excavation and offsite disposal and dual-phase (water and vapor) extraction, addressed soils with the highest VOC concentrations (generally above 10 mg/kg of total VOCs) located beneath and immediately to the east of the main manufacturing building. The SSRA demonstrated that VOC concentrations currently present in surface and subsurface soils do not exceed non-residential direct contact screening levels. COCs detected above screening levels in soil remaining on the property are arsenic, mercury, and polychlorinated biphenyls.

5.2.2 Groundwater

COCs in soil have migrated to the groundwater system. *In situ* treatment of shallow groundwater has been conducted in the area east of the main building with the highest VOC concentrations. The removal or treatment of unsaturated soil and groundwater with the highest VOC concentrations has reduced potential contaminant flux to and through the groundwater system.

Groundwater on the property is not used as a source of either potable or non-potable water. Institutional controls are planned that would ensure that groundwater is not used onsite in the future.

VOC-containing groundwater has migrated offsite to neighboring properties. In areas with VOC-affected groundwater, an alternative water supply has been provided. A groundwater monitoring program is being implemented to ensure that any changes in groundwater quality are detected.

5.2.3 Soil Vapor and Indoor Air

The existence of impacted soil and shallow groundwater onsite may result in the presence of VOC-containing vapors in soil pore spaces beneath buildings. VOCs were detected in sub-slab soil vapor samples and indoor air samples collected from the current onsite building. Indoor air in the warehouse facilities to be constructed as part of the planned site development, or other future buildings, could potentially be affected by these COCs. A vapor barrier and vapor mitigation system will be installed in the warehouse buildings constructed in the affected areas of the site.

5.3 Potentially Exposed Populations

As indicated above, manufacturing operations have ceased at the site, and a small number of office employees remain on the property into the near future. Current potential receptors include facility office workers, visitors (including child or youth intermittent visitors), or trespassers. Visitors and trespassers would generally access the site with much lower frequency and duration, relative to facility office workers. Among the current potential receptors, facility office workers are likely to be present with the highest frequency, resulting in the greatest potential exposure. Actual exposure to COCs in soil is minimized by the presence of the buildings and pavement, which prevent contact with soil over much of the property.

The planned redevelopment to a commercial facility will involve the presence of construction workers on the property, with excavation of soil expected to a maximum depth of up to 4 feet bgs. Over the long term, future uses of the property will be commercial, with the associated presence of commercial facility workers or visitors inside or outside of the warehouse buildings. Institutional controls to prevent residential use of the property or use of groundwater as a source of drinking water will be implemented as part of subsequent remedial measures.

Groundwater containing COCs at concentrations above MCLs has migrated off the property, affecting residential wells that use the groundwater from certain portions of the aquifer system as a potable water source. Risks to this receptor category have not been evaluated quantitatively, although consumption of water with COCs above MCLs is presumed to result in potential risks. In affected areas, an alternative water source has been provided. A groundwater monitoring program is being implemented so that this exposure pathway can continue to be evaluated.

The following receptors on the property were considered in the SSRA (WSP 2015):

- Current or future facility workers (indoor or outdoor)
- Current or future child or youth intermittent visitors
- Future construction workers

Additional receptors could potentially be affected by impacted media but are likely to have lesser exposure than the receptors listed above. For example, trespassers would be expected to have less exposure than facility workers. Utility workers may be on the property to conduct short-term installations or repairs, but would likely be on the property for a shorter duration than construction workers.

5.4 Exposure Pathways for Human Receptors

The presence of COCs in soil and groundwater could result in the following exposure pathways:

- Exposure to COCs in soil through the ingestion, dermal contact, or inhalation routes may affect current or future facility workers, current or future visitors, and future construction workers.
- Inhalation of COCs originating in soil or groundwater and migrating to indoor air, via vapor intrusion into buildings, may affect current or future facility workers and visitors.

Direct contact with soil by facility workers and visitors would only be expected to involve soil near the surface. Surface soil (as well as subsurface soil) does not contain VOC concentrations exceeding screening levels for non-residential direct contact. (It should be noted for the SSRA, potential exposure to all affected soil [0-15 feet bgs] was considered as a conservative, worst-case assumption.) Although vapor intrusion could be a complete exposure pathway under current site conditions, this pathway will be eliminated by the implementation of engineering controls as part of the site redevelopment. The anticipated controls include a vapor barrier and vapor mitigation system in future site buildings constructed over VOC-containing soil and groundwater.

Exposure pathways involving onsite groundwater are not complete. Groundwater is not used as a source of potable or non-potable water, and the implementation of institutional controls will ensure no future use of groundwater from onsite water supply wells. The water table occurs at depths of 10 to 15 feet bgs, which is deeper than any foreseeable construction or utility work; therefore, no direct contact with groundwater will occur during these activities.

As previously discussed, groundwater containing site-related COCs has migrated off the property. This results in a potential exposure pathway involving residents who use groundwater from certain portions of the aquifer system as a source of drinking water. However, residents with impacted wells have been provided with an alternative water supply.

The SSRA (WSP 2015) included a quantitative evaluation of human health risks from the soil direct contact pathway for a facility worker, child or youth intermittent visitor, or construction worker, and from vapor intrusion for a facility worker or visitor. The risks were found to be less than the target levels (hazard index of 1 and cancer risk of 1×10^{-5}).

5.5 Ecological Receptors

The closest body of surface water is Stony Run, which crosses the western portion of the site. The 100-year flood plain of Stony Run includes a portion of the parking lot northwest of the main building. Stony Run flows north across Dorsey Road, located approximately 2,000 feet north of the Kop-Flex property, through the Baltimore Commons Business Park and Patapsco State Park before discharging into the Patapsco River, 7 miles to the north. Wetlands (other than areas along Stony Run) are not present on the former Kop-Flex property.

COCs in the shallow groundwater zone could potentially migrate with groundwater flow to the west-northwest and discharge into Stony Run. Another potential transport mechanism that could affect the stream is erosion of surface soil containing COCs. The transport of COCs into Stony Run and its sediments could result in an exposure pathway involving freshwater aquatic organisms such as benthic macro-invertebrates or fish present in the stream. Terrestrial fauna (reptiles, amphibians, birds, and mammals) may also use the stream area as a source of food and water, or habitat, could also potentially be exposed to COCs reaching the stream ecosystem. However, the main COCs present (e.g., chlorinated VOCs) have a low potential for bio-concentration and have not been detected in surface water samples collected from the stream area.

Soil containing COCs is primarily located at depths of greater than 5 feet beneath or to the east of the former manufacturing building. Based on current and planned future development, the property consists mostly of areas covered by buildings, paved parking lots and roadways, and grass or other landscaping. Releases to soil on the property have not occurred in locations that serve as a habitat for terrestrial plants and animals. Given the planned development, the VOC-affected soil will be predominantly beneath buildings and surface pavement. Given the depth to the water table (10-15 feet bgs), exposure to VOC-containing groundwater by ecological receptors does not occur.

The SSRA (WSP 2015) included a screening-level ecological risk assessment. The screening assessment identified no significant ecological risks at the site.

6 Cleanup Criteria

The cleanup criteria for site COCs in groundwater are provided below. These numeric cleanup levels will be used to demonstrate that hydraulic control of the VOC-affected groundwater has been achieved but not to demonstrate cleanup of the impacted water-bearing zones at the site. As discussed above, soil cleanup has been completed and the risk assessment did not identify any unacceptable risk to current and future site occupants.
As previously discussed in Section 3, the groundwater COCs consist of chlorinated VOCs and 1,4-dioxane. Using the aquifer designations provided in the MDE Cleanup Standards, both the Surficial and Lower Patapsco units meet the definition of a Type I aquifer in the state of Maryland. Given this classification and non-applicability of any exception described in the aforementioned MDE guidance, the cleanup criteria selected for the VOCs, excluding 1,4-dioxane, are the numeric groundwater standards for Type I/II aquifers (Table 1 of the June 2008 interim final guidance).

The cleanup criterion for 1,4-dioxane, which is not included in the list of VOCs with established groundwater cleanup standards, was determined from an evaluation of calculated risk-based concentrations in groundwater. Using the current default exposure factors developed by USEPA and a target cancer risk of 1E-5, the calculated risk-based criterion for 1,4-dioxane is 7.8 µg/l. This value assumes the exposure pathway is from direct ingestion of the chemical via the drinking water source. (Other potential exposure routes for 1,4-dioxane in groundwater [*e.g.*, dermal absorption from bathing or inhalation of volatiles during showering] make a negligible contribution to human health risk.) Given the depth to groundwater and placement of a groundwater use restriction on the property, the direct ingestion exposure pathway would be incomplete for potential onsite receptors. For any groundwater discharged to Stony Run with 1,4-dioxane concentrations greater than 7.8 µg/l, the surface water levels would rapidly decrease in response to mixing with flow from upstream areas south of the site. Based on these conditions, an alternate, property-specific cleanup criterion of 15 µg/l, or approximately 2x the calculated risk-based level, is proposed for the site.

Based on the aquifer designation and MDE risk evaluation, the following numeric cleanup standards are proposed for groundwater at the site.

COC	Proposed Cleanup Standard (µg/l)
Chloroethane	3.6
1,1,1-TCA	200
1,1-DCA	90
1,1-DCE	7
1,2-DCA	5
Tetrachloroethene	5
Trichloroethene	5
cis-1,2-DCE	70
Vinyl Chloride	2
1,4-Dioxane	15

The groundwater response activities described in the RAP will result in the removal and treatment of site-related VOCs present in the aquifer system at the site. The treated water will be discharged to Stony Run in the northwestern portion of the property and, thus returned to the local hydrologic system. In additional to monitoring individual VOC concentrations, the total VOCs discharged to Stony Run will meet a limit of 100 µg/l, as per the August 12, 2015, correspondence from Marjorie Mewborn of the MDE Water Management Administration concerning the pending NPDES permit. In addition to the active remedial measures, institutional controls – groundwater use restriction – will be instituted for the property to mitigate any human health risks associated with exposure to VOC-impacted well water.

The numeric cleanup criteria for the cessation of the hydraulic containment systems and activities specified in the MDE-approved Groundwater Monitoring Plan for evaluating system performance will be reviewed every three years. As part of these 3-year reviews, new or alternate cleanup standards may be proposed for ceasing the operation of one or both of the groundwater collection and treatment systems.

7 Response Action for Soil and Groundwater

7.1 Soil Remedial Technology and Selection Rationale

As mentioned in Section 5 and the SSRA (WSP 2015), soil concentrations are below the non-residential cleanup criteria or do not pose a significant risk; therefore, no active remediation is required beyond the remedial actions previously completed. Engineering and institutional Controls will be implemented to maintain the protectiveness of the response action, as discussed in Section 8. Although engineering controls for vapor intrusion are not required based on the risk calculations, the evaluation was specific to the current facility building. For the proposed buildings, the SSRA recommended further evaluation or implementation of engineering controls to prevent vapor intrusion. A soil management plan (Appendix E) was prepared for soil excavation activities during property development in areas where VOC-containing soil material may be present in the shallow subsurface.

The objective of the engineering and institutional controls is to reduce the potential risk of exposure to residual contaminants in vadose zone soils through direct contact and vapor intrusion. Procedures (including recordkeeping) for the inspection and repair/maintenance of the vapor mitigation measures or other engineering controls will be specified in the Site Management Plan. In addition, soil management procedures that allow for safely conducting soil excavation activities will be include in this plan.

7.2 Groundwater Response Action

The proposed groundwater response action is containment of VOC-affected groundwater using groundwater extraction and treatment. The following subsections present the remedial alternatives evaluation and descriptions of the proposed response action, land use controls, and post-remediation requirements.

7.3 Groundwater Response Action Objectives

Groundwater Response Action Objectives (RAOs) were developed to establish goals for protecting human health and the environment. Overall, the goal of the groundwater response action is to prevent potential human and ecological exposure to VOCs present in the aquifer system at the site. Specific RAOs for the remedial actions selected for the VOC-impacted groundwater include:

- controlling potential migration of groundwater with VOCs exceeding applicable human health criteria beyond the Kop-Flex property boundary
- restricting groundwater use on the former Kop-Flex property to prevent potential exposure to VOCs present at concentrations above applicable human health criteria
- reducing concentrations of VOCs in the aquifer system

Mass removal from the groundwater system will be facilitated by the recent excavation of shallow soil containing source-type VOC concentrations, which will serve to reduce further migration of constituents to the saturated zone, and the injection of EZVI into the subsurface to the east of the building where excavation was not practical. The achievement of these remedial action objectives will satisfy the requirements of the MDE VCP for the protection of human health and the environment, and will be consistent with commercial use of the property.

7.3.1 Risk Reduction

Potential exposure pathways for current and future receptors were described in Section 5 of this document and the SSRA (WSP 2015). Since VOC transport in the saturated zone occurs exclusively in the dissolved phase, hydraulic control via withdrawals at groundwater sinks (i.e., pumping wells or collection trenches) can be implemented to contain COCs within the site boundary. The groundwater extraction systems will be located hydraulically downgradient of the source area to control any continued migration of dissolved VOCs in the aquifers. A monitoring plan will be developed to evaluate the performance and effectiveness of the hydraulic containment systems in controlling the transport of VOC-containing groundwater to downgradient areas.

Although potable water at the former Kop-Flex facility is obtained from the municipal water system, there are no currently identified restrictions on the use of groundwater at the site. As stated previously, a groundwater use restriction will be instituted for the property to mitigate any human health risks associated with exposure to VOC-impacted well water.

7.3.2 Mass Reduction

In addition to reducing human health risks, the remedial activities are designed to achieve the mass reduction RAO. Mass reduction efforts will be optimized by targeting recovery to permeable zones within the known horizontal and vertical extent of the VOC plumes and using proven technologies that remove or destroy the chemicals of concern. Given the source area locations and plume distributions, mass recovery or treatment in the Surficial aquifer will focus on the area immediately west (hydraulically downgradient) of the former manufacturing building. Recent investigation and monitoring activities have indicated the maximum VOC concentrations in the shallow groundwater zone underneath the building. For the deep groundwater zone, the majority of the VOC mass appears to be present in the southern part of the site and migrating to the south. Mass reduction in this portion of the aquifer system will be optimized by targeting removal of VOC-containing groundwater in the upper 40 feet to 50 feet of the semi-confined Lower Patapsco aquifer.

7.4 Groundwater Remedial Alternative Evaluation

Remedial alternatives were evaluated for their ability to meet the groundwater response action objectives, as well as their applicability to site-specific conditions, including access constraints, contaminants, medium, and the area/depth of concern. Alternatives that were considered include containment (permeable reactive barrier and groundwater extraction and treatment) and in situ and ex situ chemical treatments (in situ/ex situ chemical oxidation, biological reduction). The only alternative that was considered feasible was containment through groundwater collection and treatment to remove COCs. All other alternatives were determined to be ineffective with respect to addressing the contaminants and conditions at the site.

Groundwater collection and treatment is designed to prevent migration of groundwater with VOCs exceeding applicable human health criteria beyond the Kop-Flex property boundary through groundwater extraction, and remove the VOC mass from extracted groundwater through treatment prior to discharge to a surface water body. The extraction well placement and water extraction rates (Section 7.4.2.1) are proposed in accordance with the modeled conditions, and will be achieved using the selected submersible pumps (Section 9.2.1). The system's treatment components (Section 9.3) are capable of removing COCs from groundwater in order to meet the groundwater cleanup standards and discharge permit limits. Therefore, this technology is protective of human health and the environment by reducing the mobility, toxicity, and volume of contaminated groundwater at the site.

7.4.1 Groundwater Collection and Treatment

The preliminary layout of the groundwater collection and treatment system is shown in Appendix A, Sheet 2. A groundwater extraction network of three shallow extraction wells (RW-1S through RW-3S), screened within the Surficial aquifer, and two deep extraction wells (RW-1D and RW-2D), screened in the semi-confined Lower Patapsco aquifer, will contain the VOC-affected groundwater to the former Kop-Flex property. The proposed recovery well construction and operation summary is provided in Table 8.

The extraction wells in the Surficial aquifer will be located across the downgradient, or leading, edge of the shallow plume, and the extraction wells in the Lower Patapsco aquifer will be located across the downgradient property boundary for the deep plume. The total estimated groundwater flow to achieve the response action objectives is 79 gpm (see Section 4.2). Using a safety factor of 1.2, the system's maximum design flow is 95 gpm.

Extracted groundwater will be piped to a treatment system that includes an transfer pumps, bag filters, synthetic resin system for VOCs and 1,4-dioxane removal, and caustic injection system for pH buffering. Additional treatment equipment, including iron sequestration unit and an ion resin exchange system for metals removal, may be incorporated into the system to maintain treatment equipment performance and/or meet the NPDES permit discharge requirements. Alternate VOCs and 1,4-dioxane treatment equipment, including equalization tanks, air stripper, and advanced oxidation process, may be incorporated into the system in place of the synthetic resin equipment, pending bench-test and pilot test evaluation. As discussed in Section 10.1.1, the site currently operates under State Discharge Permit No. 07-DP-3442 and NPDES Permit No. MD 0069094 for discharges from groundwater remediation activities. The most recent permit was issued on July 1, 2009, and expired on June 30, 2014. No discharge will be performed until the NDPES permit renewal is issued by MDE. The design of this system assumes the discharge permit effluent limits and monitoring requirements (Table 10) in the renewed permit will be consistent with the most recent permit, as well as the groundwater cleanup standards. Based on MDE Air and Radiation Management Administration (ARMA) regulations, no treatment will be required for the off gas generated through the synthetic resin's on-site regeneration process or alternate air stripper (see Section 10.1.3). Therefore, off gas from these operations will be discharged directly to the atmosphere. The treatment system will be located within an equipment building with interconnected wiring and plumbing installations completed by the equipment vendor. Following treatment, the water will be discharged to Stony Run via Outfall 001, in accordance with the recent NPDES permit (Appendix A, Sheet 2). The estimated effluent water concentrations are provided in Table 11. Sections 7.4.2 and 9 of this report provide a summary of the design rationale, criteria, and calculations that were used to select and size the pumping, conveyance, and treatment equipment that will comprise the proposed hydraulic containment systems.

Groundwater monitoring activities to be performed during system operation are specified in the Groundwater Monitoring Plan accompanying the RAP.

7.4.2 Rationale for Technology Selection

7.4.2.1 Extraction Well Placement and Flow Rate

The extraction well placement and design flow rates are presented below and based on the aquifer testing and predictive flow simulations presented in Sections 4.1.2 and 4.2. The proposed extraction well locations are shown in Appendix A, Sheet 2, and the flow rates are provided in Appendix A, Table A-1.

In accordance with the flow simulations for the Surficial aquifer (Section 4.2.2), three shallow extraction wells (RW-1S through RW-3S) will be installed immediately west of the former manufacturing building to prevent the potential transport of VOCs above the applicable groundwater quality criteria to the Stony Run drainage area. Based on the final simulated pumping rate, a sustainable pumping rate of 3 gpm per well (combined flow of 9 gpm), is proposed to provide containment of VOC-impacted groundwater in the Surficial aquifer.

Two deep extraction wells (RW-1D and RW-2D) will be installed along the southern property boundary to contain the inferred extent of the VOC plume extending offsite to the south-southeast (Section 4.1.2.2). A sustainable pumping rate of 35 gpm per well, with a combined flow rate of 70 gpm, is estimated to provide containment of VOC-impacted groundwater in the Lower Patapsco aquifer.

7.4.2.2 Mass Loading Rates

Mass loading rate estimates serve as the basis for the treatment system design and required treatment efficiency. The recent groundwater quality data from shallow and deep monitoring wells located within the proposed system's capture area, and the predicted flow rates for each extraction well and the combined flow, were used to estimate dissolved VOC and inorganic mass loading rates for the influent to the treatment system.

Due to variability in the water quality between extraction wells, the influent mass loading was estimated under two scenarios:

- Anticipated Influent Mass Loading Rate: the summation of the mass loading rates from each extraction well, assuming the anticipated concentration and anticipated flow rate (79 gpm).
- Maximum Influent Mass Loading (Worst Case): the maximum anticipated concentration of a constituent from any of the individual extraction wells multiplied by the maximum flow rate (95 gpm).

The mass loading for the treatment system influent was then estimated for each scenario as the concentration multiplied by a flow rate. The estimated mass loading rates are provided in Appendix A, Table A-2.

7.4.2.3 Treatment Requirements

The treated effluent discharge water shall meet the requirements set forth in the NPDES permit at the time of discharge (see Section 10.1.1). The effluent results shall also be consistent with or below the groundwater cleanup standards (Section6). The effluent limits and monitoring requirements for the most recent NPDES permit are provided in Table 10, and the estimated effluent concentrations are provided in Table 11.

7.4.2.4 Site-Specific Conditions Affecting the Design

Site-specific conditions will affect the system configuration and installation of the subsurface piping. As depicted in Appendix A, Sheet 2, subsurface and overhead utilities transect the proposed lay-out for the conveyance piping. Furthermore, the exact location, and in many instances direction, of subsurface utilities are currently unknown. Therefore, all efforts will be made to identify and locate utilities prior to starting construction and care will be taken when excavating above or within the proximity of any utility identified at the site. Well and piping locations may be adjusted during construction of the system to accommodate unanticipated site conditions, and extraction wells will not be installed within 10 feet of any property boundary.

7.5 Proposed Deed Restrictions and Land Use Controls

Given the current soil conditions and results of the updated SSRA, institutional controls will be implemented to limit potential future human exposure to subsurface soils containing residual VOCs. These controls will include restricting the property to commercial use and prohibiting residential use through the recordation of an environmental covenant the land deed.

As discussed in Section 2.6.2, potable water at the former Kop-Flex property is obtained from the municipal water system; however, there are no currently identified restrictions on the use of groundwater at the site. The environmental covenant for the property will include a groundwater use restriction to reduce the potential for:

- Use of and exposure to the VOC-impacted groundwater
- Any artificial penetration of the groundwater-bearing unit(s) containing affected groundwater that could result in potential cross-contamination of clean groundwater-bearing units
- Installation of any new groundwater wells on the Property, except those used for investigative or remediation purposes and approved in advance by MDE
- Use of groundwater for any purpose (including drinking and washing) and the release of groundwater to surface water bodies, whether such release is the result of human activities or is naturally occurring
- Use of the property for other than commercial activities

This institutional control will be implemented following the construction of the new warehouse buildings and documented in the Groundwater Construction Completion and Implementation Report to be submitted to MDE.

Additional institutional controls required by MDE may be included in the Certificate of Completion based on the exposure pathways, site conditions, or quality of implementation or documentation provided.

7.6 Response Action Implementation

The contract purchaser (TC Harmans Road LLC) will be responsible for the demolition of the existing buildings and implementation of the institutional and engineering controls (e.g., passive sub-slab venting system) that constitute the soil response action during the re-development of the site. In addition, TC Harmans Road LLC will be responsible for providing MDE with all available information necessary for attaining the Certificate of Completion for the soil response action, including approval of a Site Management Plan and the following:

- Demolition
- Installation of the new slab and passive sub-slab venting systems
- Soil management plan adherence and soil disposal as needed
- Site maintenance plan adherence
- Recordation of environmental covenant

EMERSUB 16 LLC will be responsible for the successful implementation of the groundwater response action for the site, including submittal of the Groundwater Construction Completion and Implementation Report and Operations and Maintenance (O&M) Plan. Following system installation and start-up, EMERSUB 16 will conduct the necessary monitoring and reporting related to the operation of the groundwater collection and treatment system at the site.

7.7 Future Property Access

The December 2014 purchase and sale agreement between EMERSUB 16 and TC Harmans Road LLC included an access agreement that will allow access to WSP and its subcontractors for both installation of the groundwater remedial system components and performance of operation, maintenance and monitoring (OM&M) activities. A copy of the access agreement between EMERSUB 16 LLC and TC Harmans Road LLC will be provided to MDE following completion of the property transaction. The monitoring activities will include the collection of water level and water quality data from wells included in the approved monitoring program. The access requirement specified in the executed purchase and sale agreement will be binding between the parties for the expected operational period for the hydraulic containment systems. The access agreement provides for MDE access to the property to (1) inspect the site and remedial measures at any time and (2) maintain the hydraulic containment systems in case EMERSUB 16 LLC is no longer fulfilling the requirements in the MDE-approved RAP.

8 Soil Response Action

As mentioned previously, soil cleanup has been completed and the risk assessment did not identify any unacceptable risk to current and future site occupants. The soil response actions will include the implementation of land use and engineering controls to prevent future exposure to soil containing VOCs that remain at the site, as discussed in this Section. The following soil response actions will minimize the risk of exposure to soil containing VOCs that remain at the site.

8.1 Soil Management Plan

The Soil Management Plan (Appendix E) was developed to identify the procedures for safely conducting soil excavation activities in the area where VOC-containing soil material may still be present in the shallow subsurface. All soil movement, grading and/or excavation activities will be conducted according to the Soil Management Plan.

The final grading plan and utility plan for the proposed commercial development of the site will be provided at a later date, and will indicate areas of soil removal during development. Low concentrations of VOCs (including 1,4-dioxane) remain in the shallow soil (less than 10 feet bgs) underneath the southwestern portion of the former manufacturing building (AOC 1) (see Figure 2). All soil excavation activities in the area of the southwestern portion of the former manufacturing building shall be conducted in a manner that minimizes the exposure of potentially contaminated soil to precipitation and the flow of potentially contaminated storm water runoff to surrounding areas. If excavations are backfilled, clean soil shall be used from an off-site borrow area. Geotextile fabric or composite shall be placed on the bottom and side walls of excavations to serve as a marker and barrier between clean soil/fill and impacted soil. Soil will be disposed of at a properly permitted disposal facility licensed to accept the waste. The procedures described in the plan may be revised, as necessary, to ensure that all soil disturbance activities are conducted in accordance with applicable laws and regulations.

8.2 Engineering Controls

8.2.1 Current and Future Building Floor Slabs

The future development of the property will involve the demolition of the existing manufacturing building and construction of two (north and south) warehouse buildings separated by a truck loading area. In the new warehouse building areas, the concrete slab for the existing manufacturing building will remain in place, and a concrete floor slab will be installed over the current slab. In the new truck loading area between the warehouse buildings, the concrete slab for the existing building will be removed, and a new surface pavement consisting of both concrete and heavy-duty asphalt will be emplaced and serve as the paved surface for the truck loading and unloading activities. The thickness of the new concrete pavement adjacent to the warehouse buildings will be 6 inches. The asphalt will be installed along both sides of the surface drainage gutter running between the buildings and have a thickness of 4.5 inches.

The concrete floor slab for the planned south warehouse building will serve as a cap for the VOC-containing soils in this portion of the site. A written statement, signed by a Maryland-licensed Professional Engineer, certifying the design of the building floor slab for the south warehouse is appropriate for use as a soil cap is provided in Appendix F. Annual inspections of the south warehouse concrete floor slab will be conducted following completion of the site development. Procedures (including recordkeeping) for the inspection and repair of the building floor slab, as deemed necessary, will be specified in the Site Management Plan, which will be provided to MDE for review and approval with documentation supporting the implementation of the soil response activities.

8.2.2 Vapor Mitigation Systems

For the proposed buildings, the SSRA recommended further evaluation or implementation of engineering controls to prevent vapor intrusion. The construction plans for the property will include the implementation of engineering controls to prevent vapor intrusion, including incorporation of a passive vapor mitigation system into the construction of the floor slabs for both the north and south warehouse buildings. The vapor mitigation system will include a vapor collection system consisting of 2-inch diameter slotted or perforated polyvinyl chloride (PVC) pipe laterals spaced evenly within the gravel sub-base under the new floor slab and a vapor barrier consisting of a 20-mil polyethylene sheet placed between the gravel sub-base and new concrete floor slabs. The passive vapor mitigation system will prevent vapor intrusion by collecting any VOC vapors that may potentially accumulate in the gravel sub-base under the polyethylene vapor barrier. The collection system will be connected to 4-inch diameter solid PVC pipe on one side of the building that will be used as an inlet for ambient air and similar piping on the opposite side of the building that will run vertically to above the roofline to vent vapors to the atmosphere. Engineering plans and specifications for the sub-slab vapor venting system in both buildings are provided in Appendix G.

Annual inspections will be conducted of the passive vapor mitigation systems in accordance with the Site Management Plan prepared by the developer. Inspection documentation and regular maintenance requirements for the passive vapor mitigation systems will be provided with the final building plans, which will be included in the Site Management Plan. . The Site Management Plan will be submitted to MDE for review and approval with other documentation supporting the property redevelopment and implementation of the engineering controls.

9 Groundwater Response Action

Extracted groundwater will be transferred from the recovery wells to the equipment building, and power and control wiring will be conveyed from the equipment building to the recovery wells, via parallel lines of below ground piping or conduit. The groundwater collection and treatment system design details and calculations are provided in Appendix A.

9.1 Extraction Wells

The extraction well construction details are provided in Table 8. The extraction well depths and anticipated flow rates are based on the predictive flow simulations for the hydraulic containment system (Section 4.2).

Each shallow extraction well will be constructed of 4-inch diameter, Schedule 40 polyvinyl chloride (PVC) screen and riser. The shallow extraction wells will be installed to a total depth of approximately 60 feet bgs, with 35-foot long screens. The screened intervals will be fully saturated and fully penetrate the lower coarse-grained deposits in the Surficial aquifer.

Each deep extraction well will be constructed of 6-inch diameter, schedule 80 PVC screen and riser. The deep wells will be installed to a total depth of approximately 140 feet bgs, with 40-foot long screens. The screened intervals will be fully saturated and partially penetrate the upper, semi-confined portion of the Lower Patapsco aquifer.

Exact well depths will be determined in the field based upon the lithology encountered during drilling. The well screen will be machine-slotted with a slot size of 0.010 inches for the shallow recovery wells and 0.020 inches for the deep recovery wells. The well screens will be surrounded with a high silica content, washed and rounded sand pack. Construction diagrams for the extraction wells and wellhead vaults are shown in Appendix A, Sheet 3.

Each groundwater extraction well borehole will be equipped with a nested 1-inch diameter PVC piezometer that will be used to monitor the groundwater level for the well. Piezometer construction diagrams are also shown in Appendix A, Sheet 3.

9.2 Groundwater Extraction and Conveyance Piping

Groundwater pumping will be used to extract groundwater from the formation. Conveyance piping will transfer the extracted water from the wells to the equipment building, and transfer treated water from the equipment building to the discharge location.

9.2.1 Groundwater Extraction

Groundwater extraction will be performed using submersible pumps capable of overcoming the total dynamic head (TDH) requirement. The dynamic head for each pipe section was calculated using the following Hazen-Williams equation (Lindeburg 2003):

$\text{Dynamic Head}_{\text{, feet}} = H_{\text{STAT, feet}} + h_{\text{f, feet}} + h_{\text{m, feet}}$

Where:

$H_{\text{STAT, feet}}$ = static head

$h_{\text{f, feet}}$ = head loss due to friction

$h_{\text{m, feet}}$ = minor losses due to fittings and valves, and

$$h_{f,\ feet} = \frac{10.44 * L_{feet} * V^{1.85}_{gpm}}{C^{1.85} * d^{4.87}_{inches}}$$

Where:

L_{feet} = length of pipe

V_{gpm} = flow

C = Hazen-Williams Coefficient

d_{inches} = diameter of the pipe

The TDH was calculated for pumping from the hydraulically most distant extraction well (RW-2D) on the main header and the hydraulically most distance extraction well on the shallow wells' extension (RW-3S). A safety factor of 1.2 was applied to the anticipated flow rate for each recovery well. According to the TDH calculations provided in Appendix A, Table A-1, the pump in RW-1D will be required to overcome a TDH of 115 feet, and the pump in RW-3S will be required to overcome a TDH of 67 feet.

The Grundfos model SQ05-90 or similar electrical submersible pump has been selected for the shallow extraction well pumps P-1, P-2, and P-3, and the Grundfos model 60S30-5 or similar electrical submersible pump has been selected for the deep extraction well pumps P-4 and P5. These pumps are capable of overcoming the estimated head losses at the shallow and deep wells.

9.2.2 Conveyance Piping

The electrical supply and control wiring conduits will be installed in parallel with the water conveyance piping. The selected materials, sizing, and installation plan are provided below.

9.2.2.1 Materials of Construction

The material of construction for the conveyance piping is based on compatibility with the conveyed media and pipe bedding. Recovered groundwater will be transferred to the equipment building, and treated water transferred from the equipment building, via high density polyethylene (HDPE) conveyance piping. For leak collection and ease of future replacement in the event of pipe degradation or scaling, the untreated groundwater conveyance piping will be installed within a larger diameter HDPE carrier pipe. The electric power supply line and control wiring for operating the submersible pumps will be emplaced inside Schedule 80 PVC electric conduit.

9.2.2.2 Sizing

The electrical conduit will be sized to carry the required number and gauge of power and control wires. Power and control wiring will be installed in separate conduits.

The water conveyance piping is sized to optimize in-pipe water velocities to reduce deposition of solids and minimize the TDH required for conveyance of water from the submersible pumps to the equipment building. Therefore, the conveyance pipe diameters will vary depending upon factors such as hydraulic distance from the equipment building and flow rate over a particular section. The dynamic head calculations and pipe sizes per section are provided in Appendix A, Table A-1, and shown on Sheets 3 and 4.

The protective casing for the water conveyance piping will each be sized at least an inch larger than the inner pipe.

9.2.2.3 Installation

The electrical power and control conduits will be installed in parallel with the water conveyance piping, approximately 18 inches apart in cement-stabilized native soil. The water conveyance piping will be installed at a depth of 3 feet bgs, approximately 6 inches below the frost line in Anne Arundel County, Maryland (Anne Arundel County, 2014). The electrical supply line and control wiring conduits will be installed above the water conveyance piping, at a depth of 2 feet 9 inches bgs. The pipe bedding and compacted backfill will be prepared in accordance with Maryland Department of Transportation State Highway Administration's Technical Requirements Part III (2009). If the soil removed from the trench is not suitable for use in the pipe bedding, clean fill will be brought to the site for use as bedding material. The backfill source will meet VCP clean fill requirements as per the Soil Management Plan provided in Appendix E. Detector tape stating "Caution: Electrical Line Buried Below" and "Caution: Water Line Buried Below" will be placed above each respective conveyance pipe. A new sub-base that matches any preexisting sub-base will be constructed over the backfill. The trench cuts will be surfaced with new surface material matching the existing surface materials surrounding the trench. Any excavated material not used as backfill will be disposed of offsite in accordance with federal and state regulations.

At pipe junctions, the conveyance piping from an individual extraction well or section of wells will be connected to the main conveyance header. At each extraction well, the conveyance piping will connect with the pumps in each well vault via down-well electrical wiring and discharge hose.

9.2.3 Well Vaults, Pipe Junction Vaults, Valve Vaults, and Cleanouts

The extraction wellheads, pipe junctions, and valve connections will be housed in pre-fabricated steel well vaults. The vaults will be sealed watertight and will be capable of withstanding H-20 traffic loads. The protective casing containing each water pipe will be terminated just inside the entry point of each vault.

The wellhead will be equipped with the following components, as shown in Sheet 3 of Appendix A:

- Backflow preventer
- Ball valve with an electric actuator to regulate flow from the well onsite via a remote control unit and offsite via a Process Logic Control (PLC) system
- Shut off valve
- Vibration dampening clamp attachment on the hydraulic line to absorb shock from vehicular traffic on top of the well vault
- Pressure indicator to monitor for line obstructions indicated by water pressure increases
- Totalizing water flow transmitters to record and transmit the flow rate and total volume of pumped groundwater
- Sample port
- Cleanout port

Iron precipitation or sediment build-up may occur within the water conveyance piping upstream of the treatment system. Therefore, pipe cleanouts will be installed at all water conveyance pipe junctions and changes in direction to allow access for cleaning inside the pipes and fittings.

9.2.4 Backfill Material

The proposed response action requires soil excavation for pipe installation trenches, as well as the installation of extraction well and pipe junction vaults. All excavation and backfill soils will be managed in accordance with the Soil Management Plan (Appendix E). Any backfill source must also meet VCP clean fill requirements as per the Soil Management Plan provided in Appendix E. Excavated areas for installation of the response action will be backfilled with native soil. In high-traffic areas, Portland cement will be mixed into the native backfill soil for added stability.

Off-site backfill material is not anticipated during construction of the response action. However, should any off-site fill material be required, a clean fill sampling work plan will be submitted to MDE for approval prior to backfilling activities. Alternatively, an affidavit stating that the imported material has not been contaminated by controlled hazardous substances or oil will be obtained from the vendor and provided to MDE prior to importing the fill.

The source of the backfill material will be documented and provided in the Construction Completion and Implementation Report.

9.3 Treatment Equipment and Discharge

The purpose of the treatment equipment is to treat recovered groundwater to meet the applicable MDE groundwater standards for COCs and effluent limits established in the pending NPDES permit, which includes a total VOCs limit of 100 μg/l (August 12, 2015, correspondence from Marjorie Mewborn of the MDE Water Management Administration). The effluent limits and monitoring requirements for the recent NPDES permit are provided in Table 10.

The following treatment equipment is included in the design:

- Filtration, for removal of suspended solids
- Synthetic resin (AMBERSORB^{TM} 560) for VOC removal, including 1,4-dioxane
- Caustic injection, for pH buffering

The following alternate or contingency equipment may be incorporated into the treatment system, if required:

- Alternate VOC and 1,4-dioxane removal process equipment, in place of synthetic resin:
  - Equalization tank, for flow equalization and settling of suspended particles
  - Air stripper, for VOC removal
  - Advanced Oxidation Process (with hydrogen peroxide and ozone) for 1,4-dioxane and residual VOC removal
- Ion exchange resin, for metals removal
- Iron sequestering, to reduce formation of iron precipitate
- Liquid-phase granular activated carbon (GAC), for supplemental VOC removal

Additional pre-design testing will be performed to finalize the equipment required to meet the treatment objectives. For example, bench and on-site pilot studies will be performed to select the most appropriate treatment equipment (or combination of equipment) for VOCs and 1,4-dioxane removal (e.g., synthetic resin, air stripping, advanced oxidation). Also, the pre-design studies may include collection of additional geochemical parameters which may impact the treatment equipment's efficacy.

The following sections describe the treatment equipment, as well as the contingency equipment, included in the groundwater response action. Conceptual process diagrams for the groundwater treatment equipment are provided in Appendix A, Sheet 5.

9.3.1 Filtration

Suspended particle filtration downstream of the equalization tank was evaluated for reducing (1) precipitation of dissolved minerals within treatment equipment and (2) effluent suspended particle concentration according to the recent NPDES permit requirement. The system influent's total suspended particle concentrations under anticipated and maximum (worst case) conditions are estimated to be 1.1 mg/l and 9.5 mg/l, respectively. The average particle size is estimated at 2.67 microns under both anticipated and worst case scenarios (Appendix A, Table A-2). These influent concentrations are well below the NPDES requirement for total suspended solids (30 mg/l monthly average, or 45 mg/l maximum). Since a portion of the suspended particles will likely settle out of suspension in the equalization tank, the influent's total suspended solids concentration is a conservative estimate for the probable downstream concentrations. Based on the available data, filtration is not anticipated.

However, should the concentration of suspended solids increase, or equipment inspections identify a build-up of solids, or if the contingency for ion exchange resin is exercised, filtration units will be installed downstream of the air stripper. The filtration units will consist of one or more bag filter vessels, positioned in parallel or in series. The bag filters will remove solid precipitates that may result from precipitation of dissolved minerals within the water treated by the air stripper, thereby removing suspended solids before discharge. The first bag filter in each set will remove larger particles, while the second bag filter will remove finer particles not removed by the previous bag filter. Final mesh sizes for the filter bags will be determined during initial operation of the system. The bag filters will be monitored using pressure indicators installed upstream of every filter unit. These indicators will be used to monitor for pressure build up in the bag filter housing.

9.3.2 Synthetic Resin

AMBERSORB^{TM} 560, a synthetic media, is a treatment technology capable of meeting the treatment objectives for both VOCs and 1,4-dioxane removal. The hydrophobic media consists of a mixture of meso and macropores with a strong affinity for VOCs and 1,4-dioxane. As the influent water passes through the media bed, the organic constituents are absorbed to the media and removed from the water stream. The synthetic resin treatment will consist of a 2-vessel configuration with alternating lead and lag vessels in operation. The water stream passes through the operating vessels for a predetermined time or until breakthrough of the lead vessel occurs, at which time the lead vessel is taken off line and its media bed is regenerated. Once the media bed is regenerated, the vessel is returned to operation as the lag vessel, and the cycle is repeated.

The regeneration process removes the absorbed organic constituents from the media by processing low-pressure steam through the bed. After exiting the bed, the steam (or gas) containing the organic constituents is discharged to the atmosphere. Based on groundwater concentrations and system flow rates assumed under both anticipated (average) and worst case (maximum) conditions (see Appendix A, Table A-1), the regeneration process is anticipated to occur every 6 days and last up to 12 hours; this will be confirmed through pre-design testing to occur prior to installation. As shown in Appendix A, Table A-3, the chlorinated VOC plus 1,4-dioxane discharge rates per day of regeneration under average and maximum conditions, assuming the regeneration process takes 12 hours, are estimated at 5.1 pounds per day and 18.5 pounds per day, respectively. The discharge rates per year under average and maximum conditions, assuming the regeneration process occurs every 6 days, are 308 pounds per year and 1,127 pounds per year, respectively.

9.3.3 pH Buffering

The pH concentrations from the individual extraction wells are estimated at 4.4 to 4.9 standard units (SU). Based on the combined influent flow, the treatment system influent is expected to have an estimated pH of 4.7 SU. As this pH is outside of the anticipated NPDES permit range (6 to 9 SU), pH buffering will be included in the treatment system. The pH buffering system design includes an integrated controller, which will continuously monitor the pH, a metering pump for injecting the buffering solution, and a caustic solution (sodium hydroxide [NaOH]) storage container. The integrated controller will signal a metering pump to inject the caustic solution at a rate designed to maintain pH within the permit range.

9.3.4 Transfer Pumps

Transfer pumps will be used to transfer water through the treatment equipment. The transfer pumps will be rated for at least a minimum flow of 95 gpm and be capable of overcoming the dynamic head to reach the discharge location.

9.3.5 Effluent Discharge

The treated water will be conveyed in a single HDPE conveyance pipe and discharged into Stony Run through Outfall 001. A preliminary layout of the discharge pipe is provided in Appendix A, Sheet 2. No discharge will be performed until the renewed permit is issued by MDE. Water discharge monitoring for flow rate and water quality will be conducted in accordance with the NPDES permit. The effluent results for COCs will also be compared to the groundwater Cleanup criteria (Section 6). To minimize stream erosion, riprap will be installed in the area immediately downstream of the outfall.

9.4 Equipment Building and Utilities

A pre-engineered building, equipped with an overhead door and personnel door, will be used to house the treatment equipment, satellite waste accumulation area, and a work area for storing tools and performing maintenance activities. The building will be sized in accordance with the anticipated and contingent treatment equipment and other proposed uses. The building's approximate location is shown on Sheet 2. Electrical power will be supplied to the treatment building via a separate power drop and meter. Additionally, a public water supply connection will be provided at the building location and a phone or internet service connection will be provided to the PLC for remote monitoring, control, and autodialing capability.

9.5 Process Logic Control

The system design will incorporate telemetry and instrumentation that will provide automated operation and remote monitoring capability. Automatic actuation of the treatment system's equipment will be controlled via a computerized PLC system. The PLC will control the operation of system, including groundwater collection from the subsurface, groundwater conveyance to the treatment system, transfer of groundwater through the treatment system, and discharge of treated groundwater. The PLC will automatically deactivate the entire system in the event of an alarm condition (e.g., preventive overflow switch is activated).

Control of each component of the treatment system (local equipment) and extraction well (via cellular connection to local equipment) will be accomplished using a PLC type system. The control system will allow remote monitoring and control of the treatment system. All controls will be mounted inside a Master Control Panel that will be placed on the equipment building. Alarm conditions will be communicated via automatically delivered electronic message and/or telephone call. The equipment operation is explained as follows.

9.6 Equipment Testing and System Startup

Following installation, all pumping, conveyance, and treatment equipment will be tested to verify proper performance before startup and initial full-scale operation of the system. The groundwater conveyance piping will be hydrostatic leak tested before burial, and all treatment equipment, telemetry, and instrumentation will be calibrated and tested. During the testing, the PLC operation will also be checked to verify proper ladder logic control and signal function.

The system start-up procedure will begin by activating the submersible pump at the hydraulically furthest extraction well (RW-2D). Groundwater from RW-2D will be pumped to the equalization tank inside the treatment building in order to start the treatment process. Subsequently, the pump at the next farthest well (RW-1D) will be turned on followed by extraction wells RW-1S, RW-2S, and RW-3S, respectively. After all extraction wells are contributing to the total flow through the system, the effluent will be monitored and sample(s) collected for off-site laboratory analysis in accordance with the NPDES permit. Additional parameters (e.g., total suspended solids, hardness, etc.) may also be collected to assist with startup monitoring. The system will be turned off until results are received back from the laboratory and confirmed to be within the NPDES permit limits and the groundwater cleanup standards for COCs.

9.7 System Operation, Maintenance and Monitoring

9.7.1 System Operation and Maintenance

After completing the start-up period, long-term operation and maintenance (O&M) activities will be conducted by WSP, or its designated subcontractor, on a regular basis to ensure optimum system performance. WSP will prepare an O&M Plan for the selected treatment system that will include detailed operating and maintenance information, inspection forms, and spare parts list from the vendor(s) selected for equipment delivery and installation. The O&M Plan will be updated to include as-built design drawings, noting any necessary changes during system installation. Equipment failure and shutdown procedures will be incorporated into the system operation, and the information included with the O&M documentation.

9.7.2 System Monitoring

For continuous operation, the discharge will be monitored in accordance with the NPDES permit after the system startup and confirmation testing. Influent and effluent samples will also be collected from the treatment system on a routine basis and analyzed in accordance with permits issued for the operation of the system. At a minimum, water samples will be analyzed using methods approved for VOCs (including 1,4-dioxane) to measure dissolved VOC mass recovery and verify that discharge criteria are satisfied. The number of samples, sampling frequency, and required analysis will be determined upon issuance of permits. The sampling pertaining to system monitoring will be included as part of the operation and maintenance (O&M) activities for the system.

9.7.3 Groundwater Monitoring

Performance groundwater monitoring will be conducted periodically to gather data to evaluate the effectiveness of the groundwater collection system. The primary monitoring objective is to ensure the hydraulic control of the VOC-affected area by limiting further potential migration of VOCs in the groundwater system to off-property receptors. As part of the data analysis to determine achievement of the RAOs, the observed heads, or water levels, from the site will be compared to the modeled heads generated from predictive flow simulations.

The groundwater monitoring program will be conducted in accordance with the Groundwater Monitoring Plan provided in Appendix H. The monitoring well networks designed to gather hydrogeologic and hydrogeochemical data on the aquifer conditions during operation of the hydraulic containment systems are described in Section 3.3 of this plan and will include the installation of new or replacement wells in certain portions of the site. The monitoring frequency and field sampling methods to be used are discussed in Sections 3.4 and 3.5 of the plan, respectively. A field performance test (Section 6 of the monitoring plan) will be conducted to determine the applicability of a passive sampling method (HydraSleeve) for the collection of groundwater samples at the site.

9.8 Action Levels

The action levels for the groundwater response action include the groundwater cleanup criteria for COCs (Section6) and the NDPES permit discharge limits at the time of discharge. The limits for the most recent NPDES permit are provided in Table 10. The groundwater treatment equipment will be designed to meet or exceed these action levels, including the cleanup criterion for 1,4-dioxane; the estimated effluent concentrations are provided in Table 11. However, should the system discharge exceed an action level, the system will be shut down until a contingency measure is implemented to rectify the issue. Immediately thereafter, a confirmation sample of the system effluent will be collected to confirm treatment in accordance with the action levels.

9.9 Potential Contingency Measures for the Groundwater Collection and Treatment System

The proposed groundwater collection and treatment system is a proven technology for hydraulic containment. Groundwater flow modeling using site-specific data from the pumping tests was conducted to optimize extraction well locations and pumping rates to provide adequate capture of the VOC plumes. Potential contingency measures and equipment have been evaluated should unexpected conditions occur.

Contingency measures will be evaluated and implemented should the response action fail to contain and treat the groundwater as designed. If the groundwater collection system does not meet the containment objective, then modifications to the pumping rate(s) at extraction wells will be evaluated. If the water treatment system is not as effective as designed, then contingency treatment equipment will be considered, as outlined below. Should the treated water effluent exceed the NPDES permit limits at the time of discharge, MDE will be notified immediately. The system will be shut down until the cause of the exceedance (e.g., change in influent concentrations or removal efficiency) is determined and resolved, then an additional system effluent sample will be collected to confirm the NPDES permit limits are met.

9.9.1 Contingency Measures for the Selected Groundwater Response Action

The treatment equipment was selected based on the combined influent flow rate and water quality under assumed and worst case (maximum) concentrations. Safety factors and conservative assumptions were applied as appropriate to minimize or eliminate the need for contingency measures. However, the system is capable of being modified to accommodate the unexpected conditions.

Examples of potential contingency measures include:

- Replacement or alternate equipment (e.g., pumps, piping, or treatment equipment)
- Adjusting system flow rate (increasing or decreasing) by adjusting the pumping rate at individual extraction wells, or deactivating extraction wells
- Additional equipment:
    - Iron sequestering in the treatment system to reduce the potential for iron precipitation
    - Ion exchange resin in the treatment system to remove selected metals to achieve discharge limitations
    - Liquid-phase GAC for secondary treatment of VOCs in water

The need for contingency measures will be evaluated during operation.

9.9.1.1 Replacement or Alternate Equipment

If a component of the groundwater collection and treatment system (e.g., submersible pump, transfer pump, piping, or treatment equipment vessel) fails to operate as designed and cannot be repaired, then the inoperable equipment will be taken out of service and replaced in-kind, or replaced with an alternate model capable of meeting the response action objectives.

Equipment may also be replaced if alternate equipment demonstrates a more efficient treatment method for the given COCs. As stated previously, additional information on treatment for 1,4-dioxane will be collected as part of the groundwater treatment system pre-design studies. Equipment required for an alternate VOCs and 1,4-dioxane removal process to the synthetic resin system, including flow equalization tanks, air stripping, and advance oxidation process, is provided below.

9.9.1.1.1 Equalization Tank

A flow equalization tank will stabilize the influent flow and reduce downstream cycling of system components by providing a stable reservoir of untreated water. The residence time in the equalization tank will promote settling of suspended solids into the cone-bottom of the tank and equalize any variability in the influent's water quality concentrations. The sediment level in the cone-bottom of the equalization tank will be monitored during routine site maintenance activities, drained from the tank (as needed), and drummed for off-site disposal in accordance with all local, state, and federal regulations.

9.9.1.1.2 Air Stripper

A sliding tray air stripper will be used to remove chlorinated VOCs from the recovered groundwater by blowing air upward through holes in the trays and forcing dissolved VOCs to partition into the vapor phase. The vapor will be discharged through a stack on top of the stripper, and the treated groundwater will be pumped to the discharge manhole. The air stripper model was selected based on the assumed influent flow rate and minimum 99 percent removal efficiency.

The EZ-Tray 12.4 SS Model manufactured by QED Environmental or other equivalent was selected, which can achieve at least 99 percent removal of the key chlorinated VOCs present in the groundwater. Although an increase in system influent water flow is not anticipated, this air stripper is designed to handle flow rates up to a maximum of 120 gpm, which corresponds to 1.5 times the assumed flow rate and 1.3 times the maximum flow rate. As shown in Appendix A, Table A-4, the air stripper chlorinated VOC removal rate is estimated at 0.5 pounds per day (179 pounds per year) assuming the anticipated chlorinated VOC concentrations in groundwater, and 1.0 pounds per day (378 pounds per year) assuming the maximum (worst case) chlorinated VOC concentrations.

The manufacturer's recommended air flow rate through the stripper is 600 cubic feet per minute (cfm). Based on the water's mass loading rate and recommended air flow rate, the chlorinated VOC vapor concentration is estimated at 9.1 milligrams per cubic meter (mg/m^3) assuming the anticipated VOC concentrations in groundwater, or 19.2 mg/m^3 assuming maximum (worst case) VOC concentrations.

A 7.5 horsepower (hp) blower, sized for a maximum air flow of 1,100 cfm, will be selected, with its motor installed as either totally enclosed, fan cooled (TEFC) or explosive-proof (EXP). The motor's electrical specifications will be either 1- phase or 3-phase, with 230/460 voltage (V) for 3-phase or 230 V for 1-phase.

9.9.1.1.3 Advanced Oxidation Process

Advanced oxidation technology will be used to oxidize1,4-dioxane and residual VOCs (post-air stripping) via chemical reaction with ozone and hydrogen peroxide. The ozone dissociates and reacts with hydrogen peroxide to produce hydroxyl radicals (°OH), which oxidize the organic contaminants. After sufficient reaction time, complete mineralization of the organic contaminants to carbon dioxide and water are achieved.

The advanced oxidation reactor includes a series of injection, mixing, and reaction modules to maintain proper ratios of hydrogen peroxide to ozone (e.g., 1.5:1). The process starts with the injection of a specified dose of hydrogen peroxide into the influent water stream of the HiPOX reactor (e.g., 45 mg/l). As the water processes through the reactor, ozone is injected through multiple points in the reactor. Following each ozone injection port, the dosed fluid processes through an in-line mixer to ensure that the ozone is mixed into solution, and then through a reaction zone.

9.9.1.2 Flow Adjustments

The system flow rate may require adjustment to improve treatment efficiency or equipment operations. This will be accomplished by increasing or decreasing the pumping rate at individual wells or deactivating individual wells.

9.9.1.3 Additional Equipment

Additional equipment may be required if the actual influent concentration differs from the design, or if the equipment does not operate as designed. Additional treatment equipment components evaluated for this response action are listed below.

9.9.1.3.1 Iron Sequestering

Although iron concentrations in the system effluent are not limited by the NPDES permit, iron precipitation from extracted groundwater often leads to iron scaling or buildup of ferric iron sediment on treatment equipment. Therefore, the mass loading of iron was calculated to determine if iron sequestering was required. Based on the groundwater quality data, iron concentrations in the system influent are estimated to be 624.4 μg/l under anticipated conditions and 1,055 μg/l under maximum (worst case) conditions. Calculations presented in Appendix A, Table A-2, indicate that the mass of iron precipitate produced is estimated at 0.593 pounds per day under the anticipated mass loading scenario, and 1.2 pound per day under maximum (worst case) scenario. Based on these calculations, iron sequestering is not deemed necessary.

However, should the iron concentrations measured in the operating system water exceed the design concentrations, or excessive scaling and ferric oxide sediment be observed within treatment equipment, an iron sequestering agent could be injected into the treatment system water. The iron sequestering agent would be metered into the system prior to air stripping to keep the iron in solution and prevent the formation of iron precipitates. The metering rate will be determined based on qualitative observations of the treatment equipment (e.g., observations of iron scaling) and analytical testing for iron.

9.9.1.3.2 Ion Exchange Resin

The current NPDES permit requires monitoring for four metals (zinc, copper, nickel and lead), and includes permit maximum daily concentrations for each total (unfiltered) metal. Based on the anticipated influent concentrations, the total concentrations of all permit-monitored metals are below their respective NPDES permit limits; therefore, ion resin treatment is not anticipated. However, assuming maximum (worst case) influent concentrations, the concentration of total copper (15.4 μg/l) would be above its recent NPDES permit limit (13 μg/l). Therefore, ion resin exchange treatment is a contingency to remove divalent metals from the aqueous water stream. The influent metals concentrations will be evaluated upon system startup, and should the concentrations exceed the NPDES permit in more than one sampling event, treatment of metals using ion resin will be initiated.

Based on the design flow rate, a 60 cubic foot capacity carbon steel vessel would be required. The vessel would be filled with resin in acid, sodium or calcium ionic forms.

9.9.1.3.3 Liquid-Phase GAC

Liquid-phase GAC units may be needed after the air stripper as pre-treatment to reduce operating costs for advanced oxidation. If necessary, the GAC units will be placed downstream of the air stripper and filtration equipment, and will have a minimum design flow rate of 95 gpm.

10 Permits, Notifications, and Contingencies

10.1 Permits

Federal, state, and local permitting and emissions control requirements were evaluated for the groundwater containment system's operation[2]. Based on the proposed remedial system design, the following permit requirements were identified for a more detailed evaluation:

- NPDES General Discharge Permit
- MDE Water Appropriation and Use Permit
- MDE ARMA air emissions control requirements

10.1.1 NPDES Permit

The site currently operates under State Discharge Permit No. 07-DP-3442 and NPDES Permit No. MD 0069094 for discharges from a facility manufacturing high performance or high speed couplings and groundwater remediation activities. The permit was issued on July 1, 2009, and expired on June 30, 2014. No discharge will be performed until the renewed permit is issued by MDE.

10.1.2 MDE Water Appropriation and Use Permit

In Maryland, for sites that plan to perform an activity that withdraws water from the State's surface and/or underground waters, a Water Appropriation and Use Permit issued by the MDE Water Management Administration, Water Supply Program, may apply under Code of Maryland Regulations (COMAR) 26.17.06 and 26.17.07. Based on a review of the applicability criteria and discussions with MDE, any site which has an annual average groundwater use that exceeds 5,000 gpd is subject to the permitting requirements. Additionally, sites with an average withdraw rate of 10,000 gpd or more may be subject to a public information hearing, as well as requirements to notify contiguous property owners and certify compliance with Business Occupations and Professions Article 12, Section 205, Annotated Code of Maryland (water conservation technology).

Since the estimated groundwater withdrawal rates under both anticipated and worst case conditions exceed 100,000 gpd, a water appropriation and use permit will be required for the hydraulic containment systems. A Water Appropriation and Use Permit application will be submitted to MDE in advance of system installation. If any system operations are performed in advance of the permit approval, the average water withdraw will not exceed a maximum of 5,000 gpd until issuance of the permit.

10.1.3 MDE ARMA Air Emissions Control Requirements

The operation of two treatment equipment components, the synthetic resin system (during the regeneration process only) and alternative air stripper, result in air emissions. WSP reviewed the MDE Air Quality Permits Program regulations to determine if an air permit would be required for the construction and operation of the these components. Maryland issues General Permits to Construct, Permits to Construct, Permits to Operate, and Title V Air Permits to regulated sources of air emissions.

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[2] Any applicable permits related to the system's construction (e.g., electrical, plumbing, grading) will be secured by the Contractor in advance of construction.

All installations which are potential sources of air pollution are regulated and require a permit or approval from the MDE, except those installations which are specifically exempt under the State's Air Quality Regulations (COMAR 26.11.02.10). To allow faster processing of permits, the MDE regulates certain small stationary source installations through the issuance of an air quality General Permit to Construct. MDE has a General Permit to Construct for Groundwater Air Strippers and Soil Vapor Extraction Systems. The permit covers systems where the contamination is a result of gasoline, No. 1 and No. 2 fuel oils, kerosene, diesel, and jet fuels; and the soil is treated in place by means of vapor or groundwater extraction. Because the contamination at the subject site is the result of a release of chlorinated VOCs, the general permit does not apply at this site. There are no other general permits that would be applicable for the operation of the proposed air stripper.

WSP reviewed the MDE's sources exempt from permits to construct and operate in COMAR 26.11.02.10, and the estimated VOC discharge rate using maximum flow and maximum concentrations for the synthetic resin (during regeneration process only; Appendix A, Table A-3) and air stripper (continuous discharge; Appendix A, Table A-4). Both the synthetic resin regeneration operations and the air stripper operations meet the exemption in COMAR 26.11.02.10X based on the following:

- The proposed installation is not subject to any source-specific State or federal limitation or emission standard.
- The estimated emissions contain less than 1 pound per day of a Class I toxic air pollutant (COMAR 26.11.15.01B(4)).
- The pre-control potential to emit from the proposed installation combined with any potential increase from other installations that could be caused by the installation of the synthetic resin system or alternative air stripper, are less than 1 ton per calendar year for VOCs, each pollutant for which there is a federal ambient air quality standard, and each Class II toxic air pollutant defined in COMAR 26.11.15.01B(5).

Based on the aforementioned exemption, the synthetic resin system or alternate air stripper would not subject the site to any requirements under the Title V air permit program.

In conclusion, the installation of the synthetic resin system or alternate air stripper onsite does not appear to subject the facility to any MDE air permitting or approval.

10.2 Notifications

MDE will be informed of any changes to the project implementation schedule, as discussed in Section 11, and the construction completion of the response action, as discussed in Section 14.1. MDE will be also be notified if any previously undiscovered contaminants, undiscovered storage tanks, or other environmental concerns are identified.

10.3 Contingencies

Section 9.9 describes contingency measures for the groundwater collection and treatment system. Should unexpected site conditions be encountered (e.g., free product, buried tanks, previously unidentified contamination), a work plan addendum with a proposed response action will be submitted to MDE for approval. A public informational meeting will be held to discuss the change in remedy.

11 Project Implementation Schedule

The proposed project implementation schedule is provided in Figure 14a. Building demolition and installation of the vapor mitigation measures with the new warehouse buildings will be completed during the development of the property. Construction of the proposed hydraulic containment system is expected to begin within 90 calendar days of MDE approval of the RAP and issuance of the required permits. WSP will prepare bid specification documents for Contractors following submittal of this plan, and will submit the bid specification documents to the potential Contractors following MDE's approval. After issuance of permits, WSP will retain a qualified Contractor to install the groundwater collection and treatment system. Assuming no significant delays, the installation and startup of the proposed system should take no more than 120 calendar days to complete.

A Construction Completion Report for the soil response action and Site Management Plan will be provided to MDE within 120 days of completing the re-development of the property. For the groundwater response action, a Construction Completion and Implementation Report and O&M Plan will be submitted to MDE within 60 days of completing system installation and startup. The implementation schedule provides information on the timing for the completion of groundwater monitoring events and submittal of Operation, Maintenance & Monitoring Reports for the hydraulic containment systems. The schedule for conducting the annual inspections of the south warehouse concrete floor slab and passive sub-slab venting systems will be provided in the Site Management Plan. The Remedial Action Report will be submitted within 60 days of completion of remedial activities and decommissioning of the systems.

Weather, procurement of subcontractors, and equipment availability may affect this schedule. However, every effort will be made to adhere to the proposed schedule. Exact schedule details related to various construction activities will be prepared by the contractor prior to commencement of any construction activities. Should any modifications to the implementation schedule become necessary, MDE will be advised of the revised schedule.

12 Health and Safety

A detailed Health and Safety Plan (HASP) will be prepared and submitted to MDE prior to the implementation of the approved RAP. In accordance with MDE guidance, the plan will reference applicable regulations to the project activities (i.e. applicable sections of the Occupational Safety and Health Administration (OSHA) regulations, 29 CFR 1910 [General Industry – Hazardous Waste Site Operations, Excavations, Personal Protective Equipment, Respiratory Protection] and 29 CFR 1926 [Construction]). Components of the HASP will include:

- Appropriate personal protective equipment (PPE) and monitoring devices that must be utilized by workers to ensure that all worker protection requirements are met, and the rationale for the PPE selected.
- Site control measures that will be maintained during RAP implementation to restrict access (e.g. security guards, warning fences).
- Dust abatement or suppression methods.
- Compliance by all on-site workers with OSHA guidelines for managing contaminated material regardless of their characterization as hazardous or non-hazardous. The remedial contractor must possess the necessary certification for the transportation of any controlled hazardous substance.

13 Waste Management

Waste generated during the construction of the groundwater response action will include soil, drilling cuttings, development water, disposable sampling, and PPE. Any waste material generated during construction of the groundwater collection and treatment system will be characterized, managed, and disposed of in accordance with all local, state, and federal regulations.

14 Reporting

14.1 Construction Completion and Implementation Reports

As indicated in the previous section, a Construction Completion Reports will be submitted to MDE to document the soil response action activities and installation and start-up of the groundwater collection and treatment system. The groundwater completion report will summarize the system construction activities and include as-built drawings for the extraction well and other system components. The monitoring data gather during the start-up phase will also be provided in the report and evaluated with respect to the NPDES permit and system design parameters.

14.2 Operation, Maintenance and Monitoring Reports

OM&M reports will be provided to MDE on a quarterly basis for the first year of system operation, as provided in Figure 14b. After this initial operational period, these reports will be submitted annually. Each OM&M Report will be submitted during the first month of the subsequent quarter and include the following information:

- A summary of the quarter's operations, maintenance, and monitoring activities, including explanations for any periods of non-operation lasting more than one week
- Quarterly, annual, and historical water extraction and mass removal volumes for the system
- System monitoring results along with an evaluation of the treatment system efficiency and compliance with the discharge permit requirements
- Groundwater data collection and evaluation in accordance with the approved Groundwater Monitoring Program
- A summary of any recommended system or monitoring program changes for the coming quarter

15 Administrative Requirements

A copy of the certified zoning statement for the property is included in Appendix I. In accordance with the MDE VCP guidance, the statement certifies the current and proposed future use of the property, upon which the response action is based, are in conformance with all applicable zoning requirements.

EMERSUB 16 LLC plans to utilize Performance Bond 104775256 as financial surety to cover the activities set forth in the RAP. .The bond amount will be updated no later than 10 days after MDE approval of the RAP and before conducting any work on the property to ensure adequate funds are available to fulfill the requirements under the VCP The bond amount will be sufficient to satisfy MDE's requirements to secure and stabilize the property, if future circumstances warrant. Given the site conditions and planned property redevelopment, any activities that may be necessary to stabilize the site should be limited in nature.

16 Project Completion

16.1 Criteria for Project Completion

16.1.1 Soil

The activities outlined below will be performed to ensure completion of the soil response action at the site.

- Field oversight during development to ensure the appropriate handling and management of any VOC-impacted soil in accordance with the approved Soil Management Plan.
- Construction quality assurance oversight activities to ensure proper installation of the vapor mitigation components (vapor barrier and passive sub-slab venting system) in the warehouse buildings and building floor slab that will serve as a soil cap in the south warehouse building.
- Completion of initial acceptance tests for passive sub-slab venting systems to gather information on operation and performance.
- MDE approval and subsequent implementation of the Site Management Plan by the property developer.

16.1.2 Groundwater

The activities outlined below will be performed to ensure completion of the groundwater response action at the site.

- Collection and analysis of water level data from monitoring wells to verify the hydraulic control of the VOC plumes during operation of the containment systems.
- Regular monitoring and reporting of effluent samples from the treatment system to ensure adequate VOC removal efficiency and attainment of permit discharge limits.
- Collection and evaluation of water quality data from the perimeter monitoring wells cross-gradient and downgradient of the recovery well systems in both Surficial and Lower Patapsco aquifers to assess mass removal and ensure the capture and containment of site-related VOCs from the groundwater system.

16.2 Certification of Completion

16.2.1 Soil

Conditions related to the impacted soil that will need to be achieved prior to issuance of the Certificate of Completion include the following:

- Submittal of documentation to MDE indicating the recordation of the Environmental Covenant with the land deed on file at the Anne Arundel County Circuit Court Land Records Department that restricts the property to commercial use.
- Submittal of a Construction Completion Report for the soil response action activities to MDE (see Section 14.1). This report will include as-built construction drawings showing the installation of vapor mitigation systems and concrete floor slab cap in building areas and documentation of the characterization and disposal of any VOC-impacted soil material excavated from areas pursuant to applicable regulatory requirements, and certification of imported soil used as clean fill.

- MDE approval of a Site Management Plan that provides information on the operation and maintenance (O&M) and inspection activities for the vapor mitigation systems and building floor slab, and procedures for notifying MDE prior to any future soil disturbance activities at the Site below areas covered by the existing building slab.

TC Harmans Road LLC will be responsible for recordation of the Environmental Covenant on the land deed, and submittal of the Construction Completion Report and Site Management Plan for the soil response action. As indicated above, the implementation of the land use restriction for the property will be completed during development and the Environmental Covenant provided with the completion documentation. All areas of the Site will be subject to the institutional controls specified in the Environmental Covenant.

16.2.2 Groundwater

The conditions necessary for issuance of the Certificate of Completion for the groundwater response action include the following:

- Submittal of documentation to MDE on the recordation of the Environmental Covenant with the land deed that restricts the use of groundwater underlying the property.
- Submittal of the Construction Completion and Implementation Report (see Section 14.1), and O&M Plan for the groundwater collection and treatment systems.
- Evaluation of water level data from the following monitoring wells demonstrating the effective hydraulic control of site-related VOCs in the onsite area during operation of the hydraulic containment systems.
    - **Surficial Aquifer**

      MW-03
      MW-05R
      MW-18
      MW-38R
      MW-39
      MW-42
      MW-43
      MW-44
    - **Semi-confined Lower Patapsco Aquifer**

      MW-1D
      MW-21D
      MW-22D
      MW-24D
      MW-40D
      MW-41D

  The results of the data evaluation indicating hydraulic capture of the VOC-affected groundwater on the property will be provided OM&M reports submitted to MDE for review (see Section 14.2).
- Evaluation of water quality data from the following boundary wells in both the surficial and semi-confined Lower Patapsco aquifer during operation of the hydraulic containment systems that indicate site-related VOC concentrations below the cleanup criteria specified in Section 6.
    - **Surficial Aquifer**

      MW-03
      MW-18
      MW-39
      MW-42
      MW-43
      MW-44
    - **Semi-confined Lower Patapsco Aquifer**

      MW-22D
      MW-27D
      MW-40D
      MW-41D

> The results of the sampling data evaluation indicating attainment of the groundwater cleanup criteria for the designated monitoring points will be provided OM&M reports submitted to MDE for review (see Section 14.2).

Given the pending property transfer, TC Harmans Road LLC will be responsible for recordation of the Environmental Covenant specifying the groundwater use restriction. The implementation of the use restriction will be completed during property development and the Environmental Covenant provided with the completion documentation. All areas of the Site will be subject to the institutional controls specified in the Environmental Covenant. EMERSUB 16 LLC will be responsible for the preparation and submittal of the Construction Completion and Implementation Report for the groundwater response action and data demonstrating attainment of hydraulic control of the VOC-impacted groundwater and cleanup criteria in the designated boundary monitoring wells. TC Harmans Road LLC will maintain ownership and control of the Site during the development.

16.3 Post-Remediation Requirements

Post remediation care requirements will include compliance with the conditions specified in the Certificate of Completion and the institutional controls recorded for the Site. Deed restrictions included as part of the Certificate of Completion and will be recorded either before or no later than 30 days after issuance of the Certificate of Completion. In addition, MDE and the WSSC (for excavations and/or grading within the WSSC easement area) will be provided written notice at least 15 days prior to any planned excavation activities at the Site that will occur within areas of potentially VOC-containing soil . Written notice of planned excavation activities will include the proposed date(s) for the excavation, location of the excavation, health and safety protocols (as required), clean fill source (as required), and proposed characterization.

Continual evaluation of the groundwater monitoring data will be conducted to assess COC concentrations and determine when to terminate pumping within the aquifer units. Information on the data collection and evaluation procedures and decision approach for determining the termination and, if necessary, resumption of operation of the hydraulic containment systems will be provided in either the Operations and Maintenance (O&M) Plan to be prepared as part of the Certificate of Completion or a future OM&M Report.

After a decision is made to cease operation of the hydraulic containment systems(s), two years of quarterly groundwater sample data will be collected from the monitoring network wells to determine attainment of the cleanup standards. The collection of quarterly groundwater samples will be conducted to assess any seasonal differences or fluctuations in COC concentrations in the aquifer. The approach to determine attainment of the groundwater cleanup criteria for the COCs listed in Section 6 will be generally similar to the sequential statistical test method described in the U.S. EPA guidance document *Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Ground Water* (July 1992). If the 2 years of groundwater sampling data do not indicate attainment of the COC cleanup criteria in one or more monitoring points, additional groundwater sampling will be completed in only those wells. After collecting the additional groundwater quality data, the sampling results will be analyzed using the same approach or another statistical method selected by EMERSUB 16 and acceptable to MDE.

17 References

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18 Acronyms

μg/l	Micrograms per liter
AOC	Area of Concern
ARMA	Air and Radiation Management Administration
bgs	Below ground surface
cfm	Cubic feet per minute
COC	Constituents of concern
DCA	Dichloroethane
DCE	Dichloroethene
DPE	dual phase extraction
ESI	Environmental Simulations Incorporated
EZVI	Emulsified Zero Valent Iron
ft	Foot (feet)
ft msl	Feet mean sea level
ft/day	Feet per day
ft^2/day	Square feet per day
GAC	granular activated carbon
gpd	Gallons per day
gpm	Gallons per minute
HASP	Health and safety plan
HDPE	High density polyethylene
hp	Horsepower
K	Hydraulic conductivity
MDE	Maryland Department of the Environment
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
mg/m^3	Milligrams per cubic meter
NPDES	National Pollutant Discharge Elimination System
OM&M	Operation, Maintenance and Monitoring
PLC	Process logic control
PPE	Personal protective equipment
PVC	Polyvinyl chloride
RAOs	Response action objectives
RAP	Response Action Plan
S	Storativity
SSRA	Site-specific risk assessment
SU	Standard units
SVE	soil vapor extraction
T	Transmissivity
TCA	Trichloroethane
TDH	Total dynamic head
UVB	Unterdruck-Verdampfer-Brunnen
V	Voltage
VCP	Voluntary Cleanup Program
VOCs	Volatile Organic Compounds

Figures

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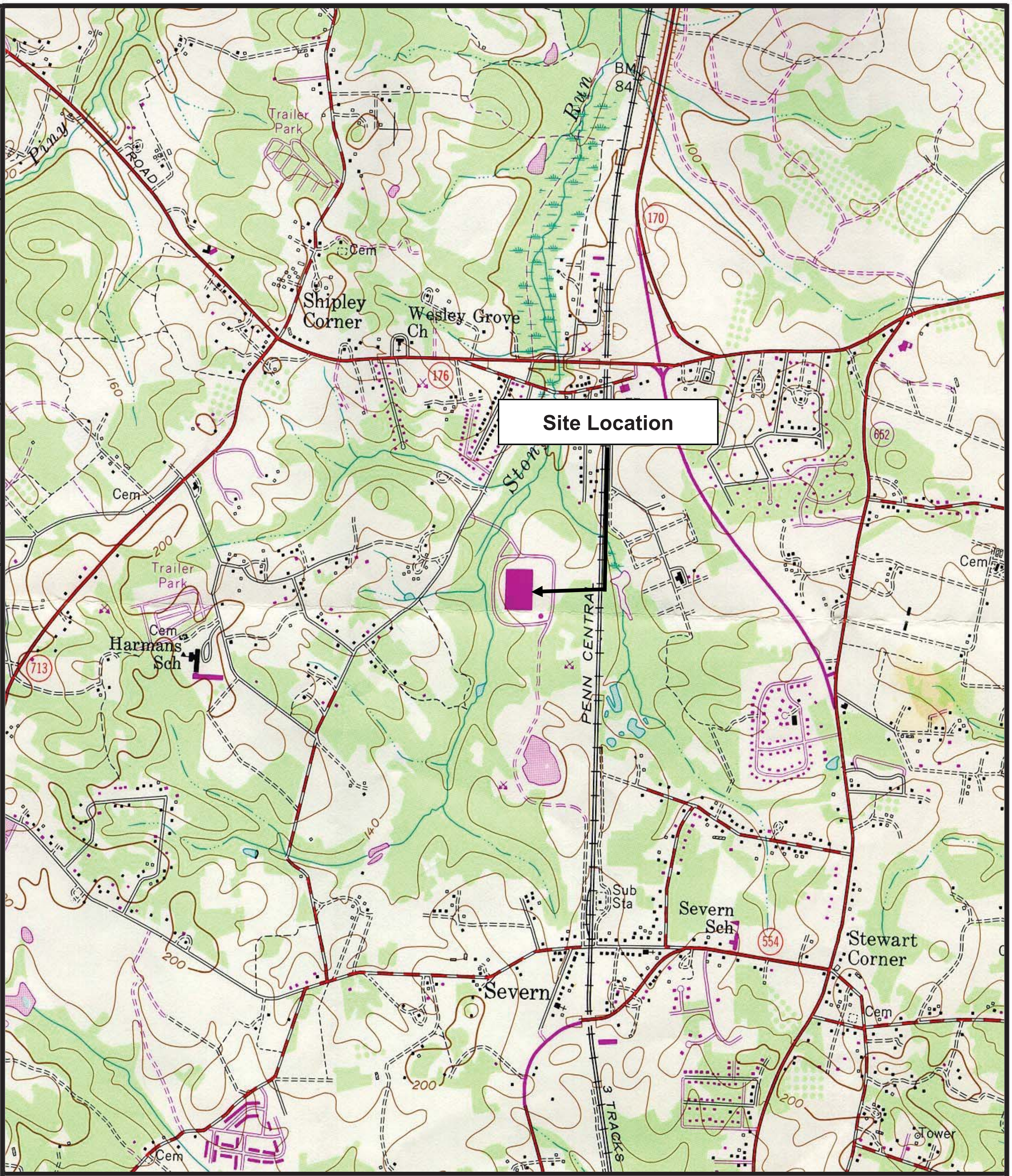

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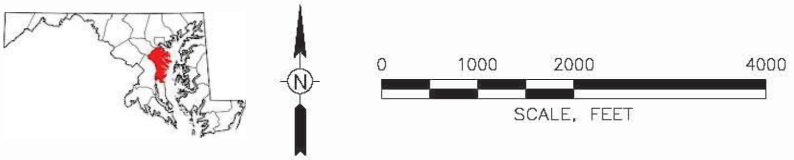

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FIGURE 1

SITE LOCATION MAP

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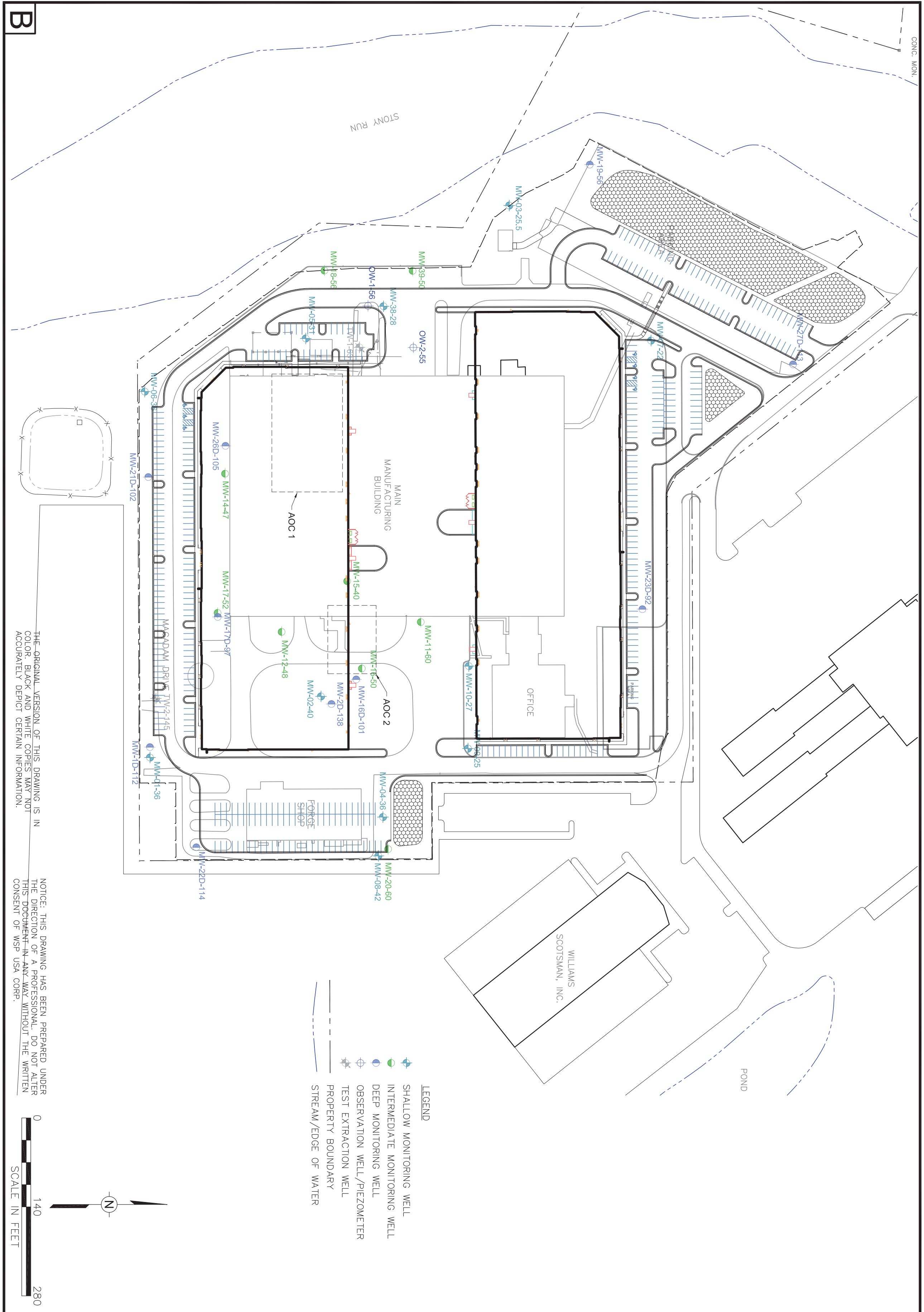

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Figure 2

CURRENT AND FUTURE SITE LAYOUT WITH
EXISTING WELL LOCATIONS

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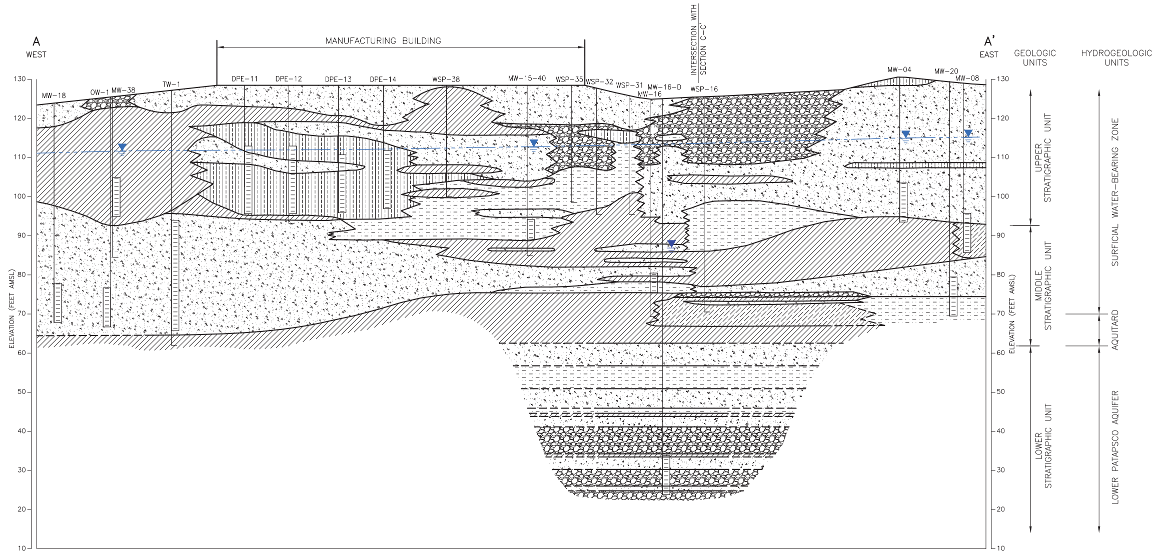
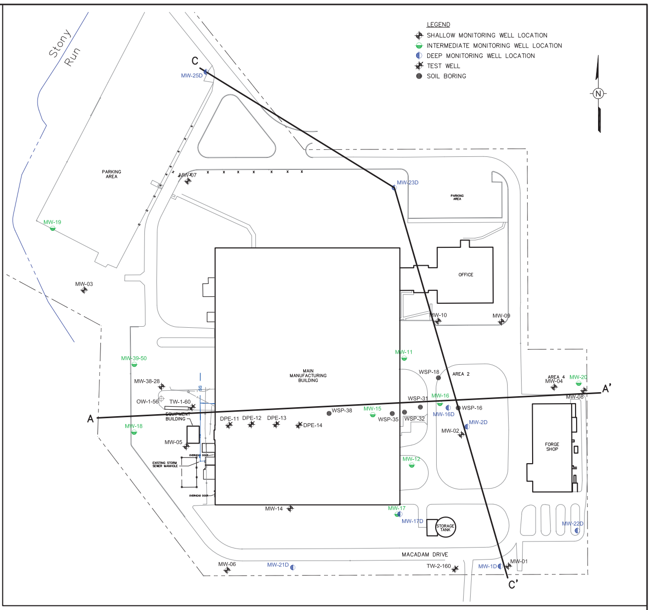
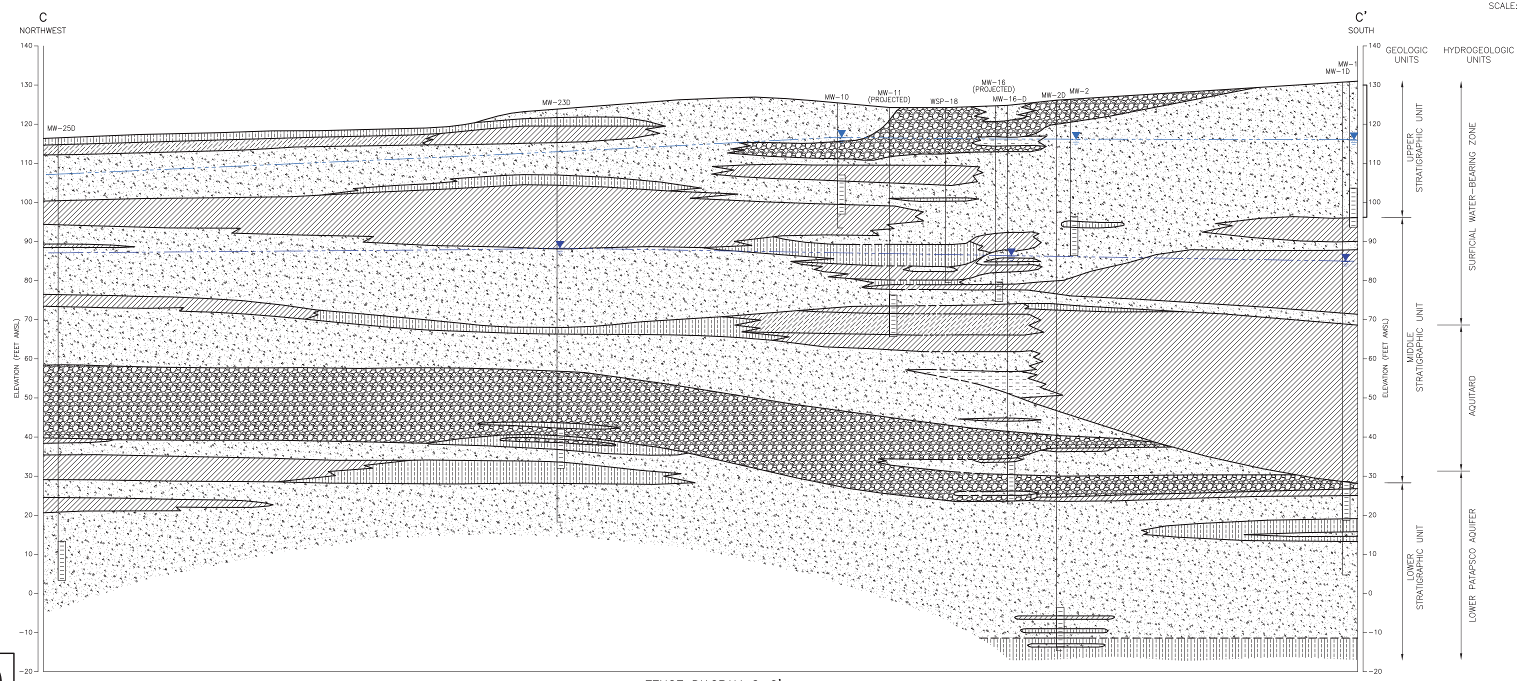


FENCE DIAGRAM A-A'



FENCE DIAGRAM LOCATIONS
SCALE: 1"=120'



FENCE DIAGRAM C-C'

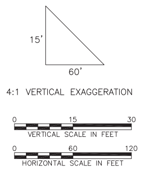
LEGEND

- ▩ GRAVELLY SAND
- ▨ SAND - SILTY SAND - CLAYEY SAND
- ▤ INTERLAYERED SAND AND CLAY
- ▥ CLAYEY TO SANDY SILT
- ▨ SANDY TO GRAVELLY CLAY
- ▨ SILTY CLAY TO CLAY

- BOREHOLE
- SCREEN
- BOTTOM OF BOREHOLE

- ▼ WATER LEVEL IN SHALLOW MONITORING WELL
- ▼ WATER LEVEL IN DEEP MONITORING WELL
- — - — SHALLOW ZONE GROUNDWATER SURFACE ELEVATION
- — - — POTENTIOMETRIC SURFACE FOR DEEP GROUNDWATER ZONE

NOTES:
1. GROUNDWATER ELEVATIONS FOR SHALLOW AND INTERMEDIATE WELLS FROM DATA COLLECTED IN JULY 2013.
2. GROUNDWATER ELEVATIONS FOR DEEP WELLS FROM DATA COLLECTED IN SEPTEMBER 2013.



4:1 VERTICAL EXAGGERATION

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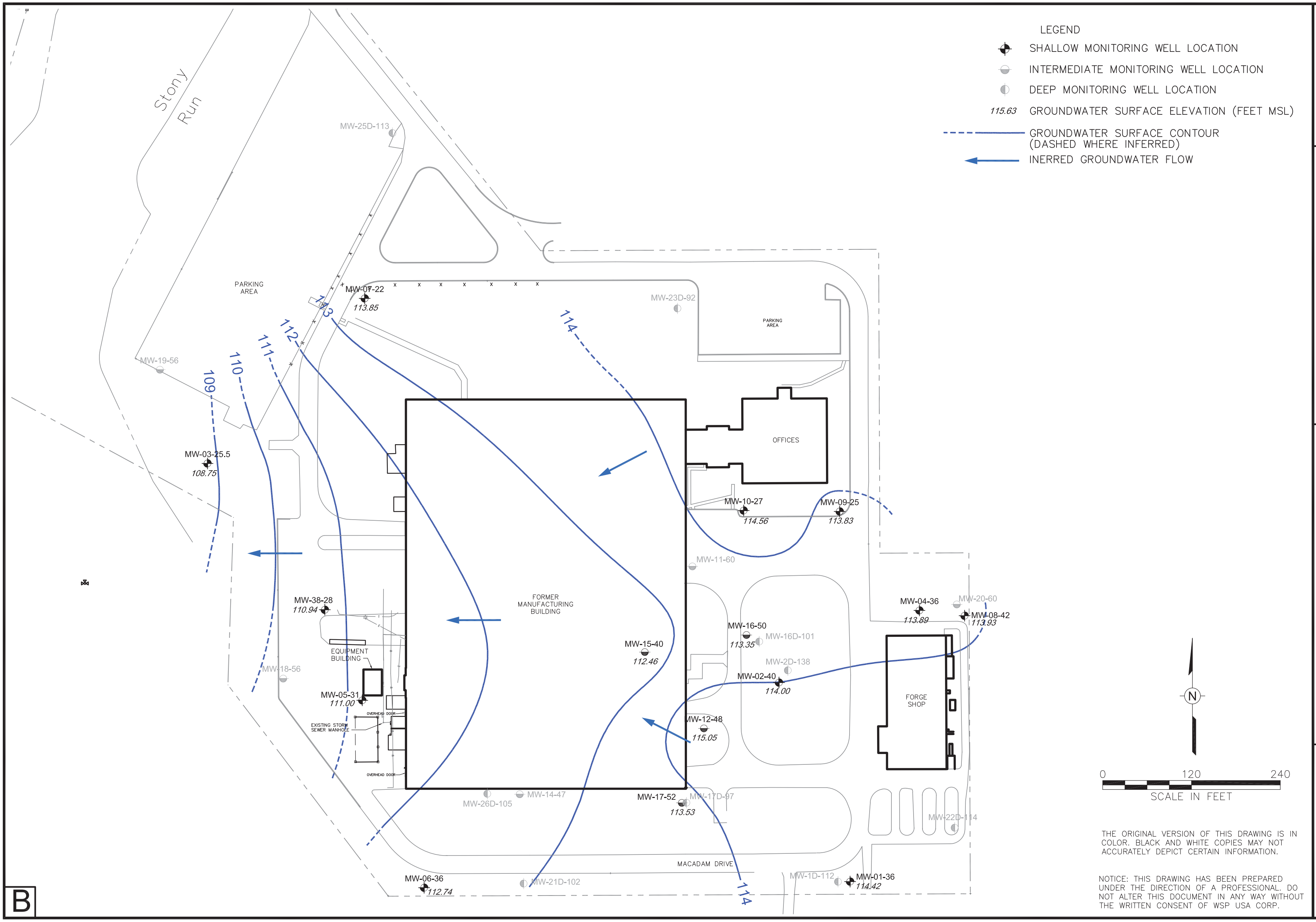

LEGEND

✦	SHALLOW MONITORING WELL LOCATION
◒	INTERMEDIATE MONITORING WELL LOCATION
◐	DEEP MONITORING WELL LOCATION
115.63	GROUNDWATER SURFACE ELEVATION (FEET MSL)
- - - —	GROUNDWATER SURFACE CONTOUR (DASHED WHERE INFERRED)
←	INERRED GROUNDWATER FLOW

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Figure 4

GROUNDWATER SURFACE CONTOUR MAP
SURFICIAL AQUIFER
DECEMBER 2014

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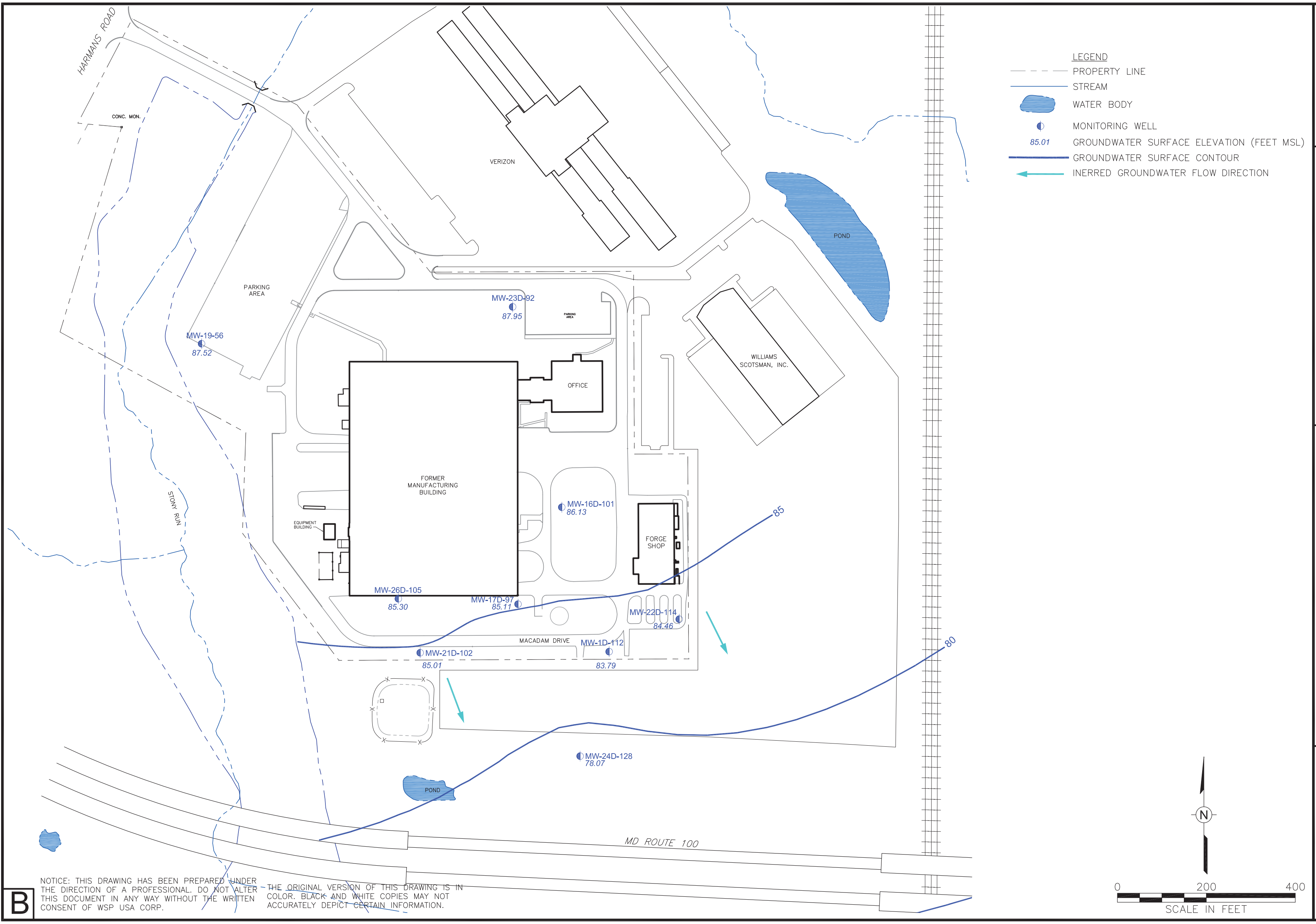

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Figure 5

POTENTIOMETRIC CONTOUR SURFACE MAP
LOWER PATAPSCO AQUIFER
DECEMBER 2014

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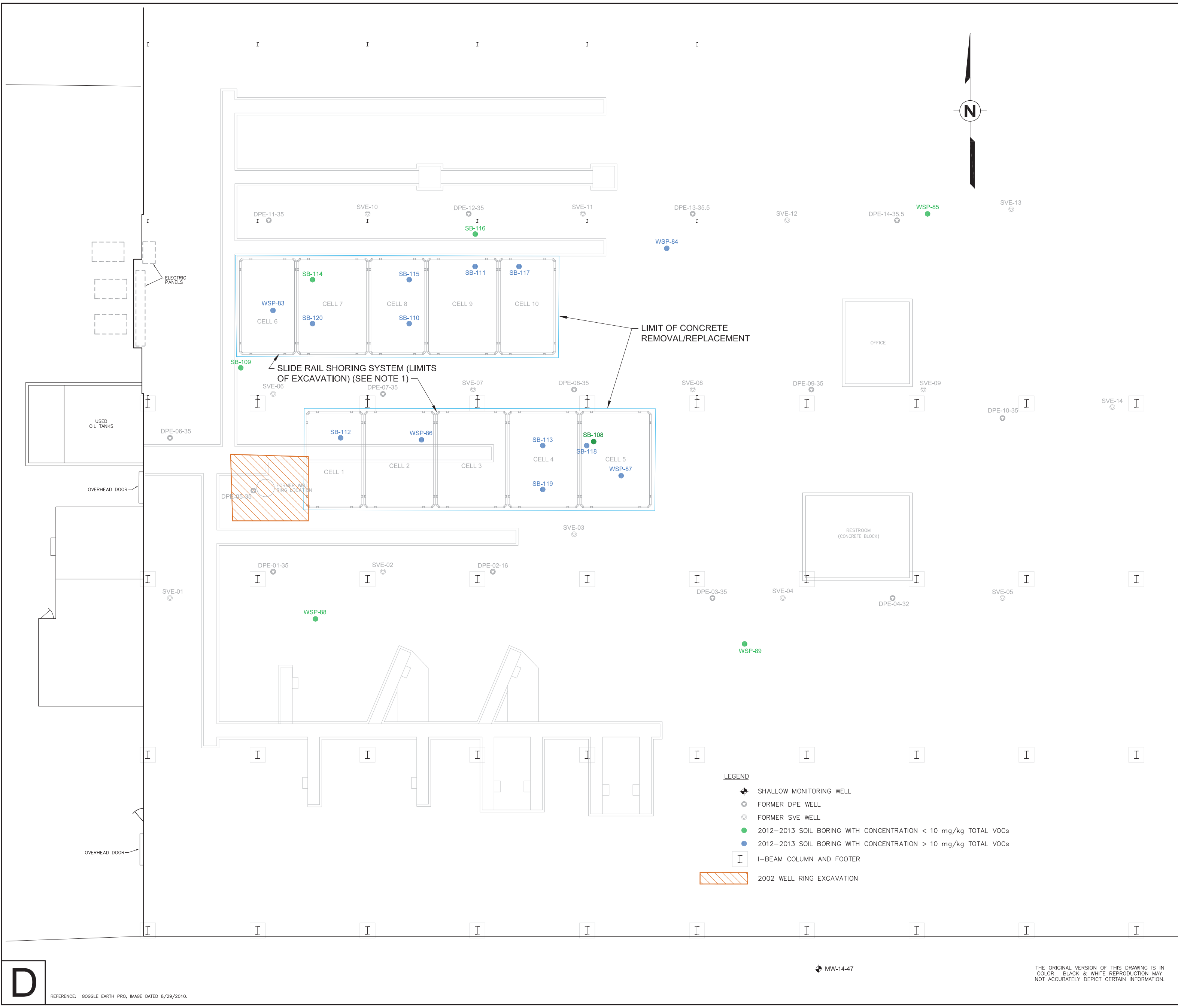

SUPPLEMENTAL SOIL
SAMPLING DATA 2012 - 2013

Location	Depth (ft-bfs)	Total VOCs (mg/kg)	1,4-Dioxane (mg/kg)
WSP-83	**6-8**	**19.4**	**19.3**
WSP-83	**10-12**	**114**	8.92
WSP-83	19.9	3.77	3.74
WSP-84	6-8	2.94	2.82
WSP-84	**10-12**	**11.6**	**<16.6**
WSP-84	20.5	2.12	1.97
WSP-85	8-9	2.48	1.49
WSP-85	11-13	1.1	<0.151
WSP-85	18	2.23	1.99
WSP-86	**6-8**	**823**	**823**
WSP-86	**10-12**	**4,460**	**43.4**
WSP-86	17	8.42	7.04
WSP-87	6-8	5.1	5.1
WSP-87	**10-12**	**13.4**	**13.4**
WSP-87	16	2.03	2.02
WSP-88	6-8	0.397	0.397
WSP-88	10-12	0.319	0.319
WSP-88	17	1.86	0.187
WSP-89	6-8	1.87	1.87
WSP-89	10-12	2.05	2.05
WSP-89	17	2.88	2.35
SB-110	**14**	**112**	**59.7**
SB-111	**14**	**10.22**	5.96
SB-112	**12**	**161**	**149**
SB-113	**11**	**1,289**	**31**
SB-114	12	0.39	6.94
SB-115	**14**	**12.34**	8.1
SB-116	12	6.88	0.643
SB-117	**14**	**69.91**	**49.1**
SB-118	**12**	**81.51**	**24.4**
SB-119	**14**	**132**	**90.4**
SB-120	**14**	**47**	**42.5**

GREEN = CONCENTRATION < 10 mg/kg TOTAL VOCs
BLUE = CONCENTRATION > 10 mg/kg TOTAL VOCs
ND = NON-DETECT

NOTE:

1. EXCAVATION ADVANCED TO 15 FEET BELOW TOP OF FLOOR IN ALL SHORING CELLS.

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10 0 10 20
SCALE, FEET

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AOC 1 SUPPLEMENTAL SOIL BORING LOCATIONS, RESULTS, AND EXCAVATION LIMITS

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FIGURE 6

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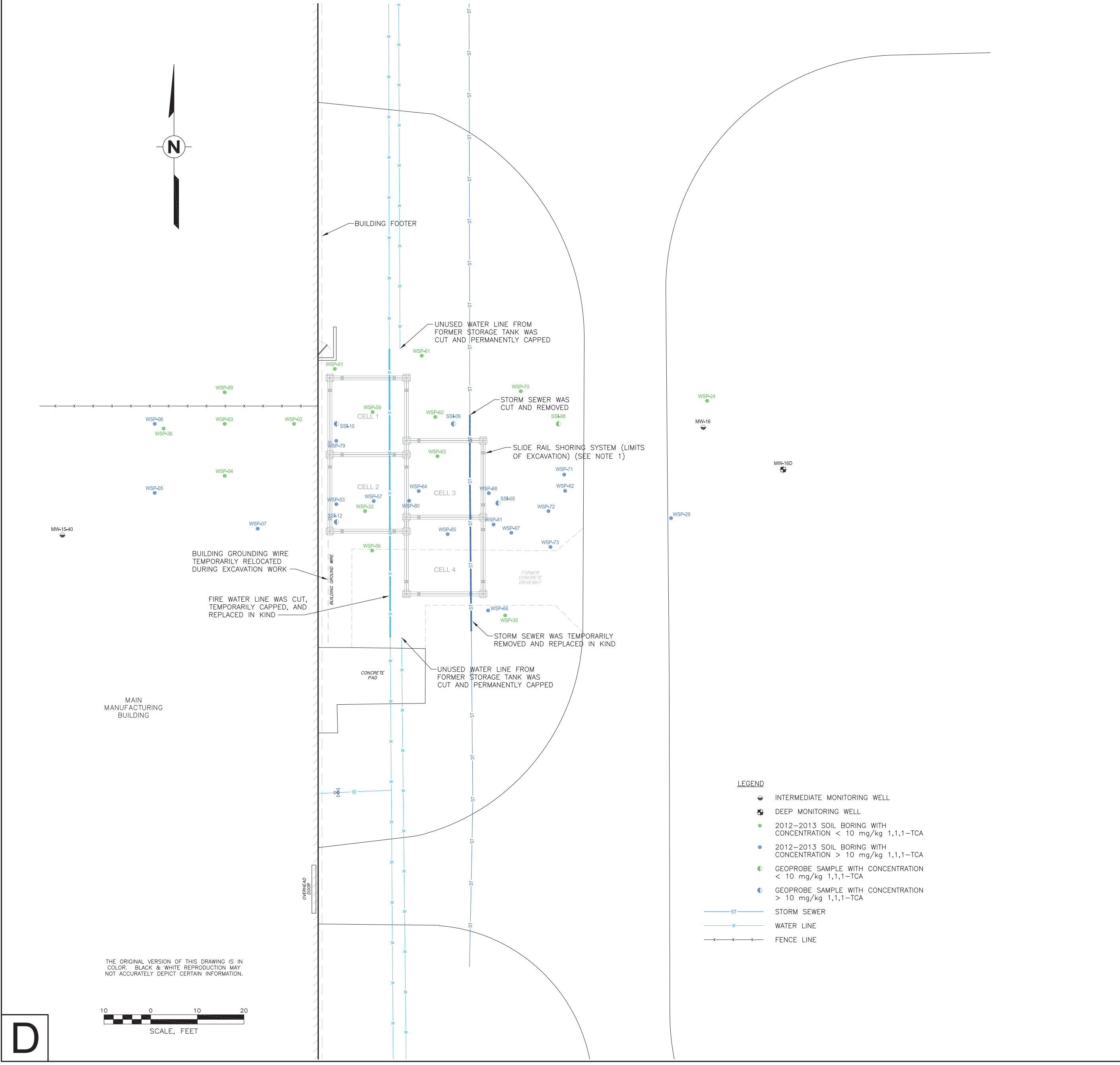

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SUPPLEMENTAL SOIL SAMPLING DATA 2012 - 2013

Location	Depth (ft-bgs)	1,1,1-TCA (mg/kg)	1,4-Dioxane (mg/kg)
WSP-79	**8.5-9**	**89.2**	ND
WSP-79	11-12.5	0.7	ND
WSP-80	**12.5-14**	**38.2**	ND
WSP-80	**16.5-18**	**21.5**	ND
WSP-81	**20-21.5**	**1,120**	ND
WSP-81	23-24.5	3.3	ND
WSP-82	**15.5-17**	**13.1**	ND
WSP-82	18.5-20	2.1	ND

GREEN = CONCENTRATION < 10 mg/kg 1,1,1-TCA
BLUE = CONCENTRATION > 10 mg/kg 1,1,1-TCA
ND = NON-DETECT

HISTORICAL SOIL SAMPLING DATA 2007 - 2008

Location	Depth (ft-bfs)	1,1,1-TCA (mg/kg)
SSI-05	**9**	**44**
SSI-08	7-8	ND
SSI-09	**8-9**	**250**
SSI-10	**9**	**3,500**
SSI-12	**13**	**29**
WSP-02	10-11	ND
WSP-03	12-13	ND
WSP-04	13-14	ND
WSP-05	**13.5-14.5**	**50**
WSP-06	**11-12**	**85**
WSP-07	**9-10**	**30**
WSP-09	7-7.5	0.03
WSP-24	31-31.5	0.43
WSP-29	**21-22**	**570**
WSP-30	19-19.5	9
WSP-32	22	7
WSP-36	15	4
WSP-51	23-24	0.08
WSP-53	**10-11**	**12**
WSP-56	21.25-23	5
WSP-57	**7-8**	**290**
WSP-59	23-24	0.04
WSP-61	21-23.5	0.02
WSP-62	15-18	0.14
WSP-63	16.5-18	0.27
WSP-64	**7-9.25**	**5,100**
WSP-65	**18.5-19**	**73**
WSP-66	**18-19**	**55**
WSP-67	**19-21.5**	**21**
WSP-68	**9.24-10**	**25**
WSP-70	13.5-15	2
WSP-71	**15-17**	**2,400**
WSP-72	**19.5-20**	**30**
WSP-73	**18-19**	**32**

NOTE:

1. EXCAVATION DEPTHS:
   CELL 1 – 20 FEET BGS
   CELL 2 – 18 FEET BGS
   CELL 3 – 21 FEET BGS
   CELL 4 – 23 FEET BGS

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AOC 2 HISTORICAL BORING LOCATIONS, RESULTS, AND EXCAVATION LIMITS

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FIGURE 7

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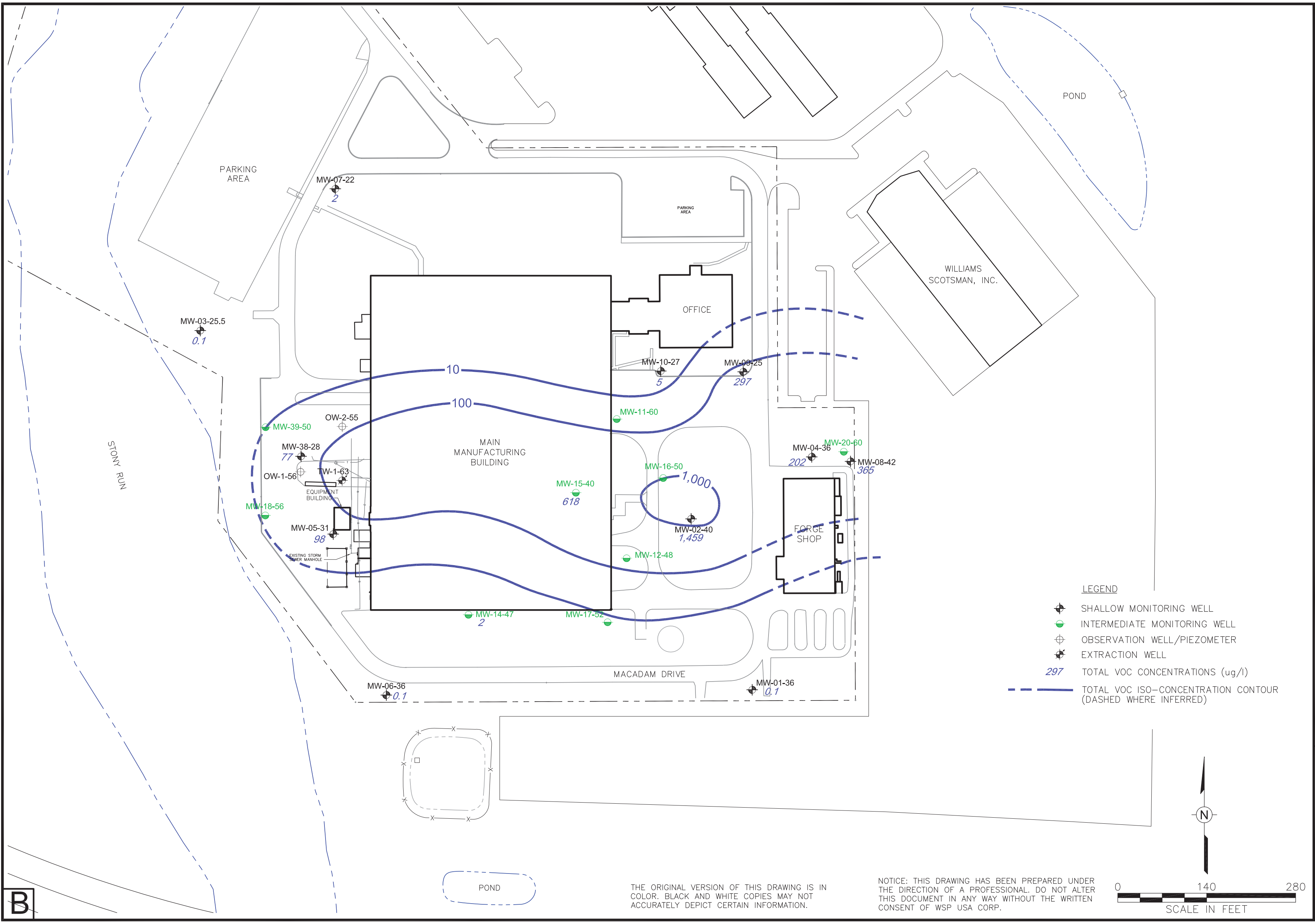

LEGEND

- ✣ SHALLOW MONITORING WELL
- ◒ INTERMEDIATE MONITORING WELL
- ⊕ OBSERVATION WELL/PIEZOMETER
- ✣ EXTRACTION WELL
- *297* TOTAL VOC CONCENTRATIONS (ug/l)
- — — TOTAL VOC ISO-CONCENTRATION CONTOUR (DASHED WHERE INFERRED)

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Figure 8

CURRENT SITE LAYOUT WITH TOTAL VOC CONCENTRATIONS IN SHALLOW GROUNDWATER (DECEMBER 2014)

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By:	EGC
Checked:	MML 4/23/2015
Approved:	
DWG Name:	00003705-225

LEGEND

- ▩ GRAVELLY SAND
- ▒ SAND – SILTY SAND – CLAYEY SAND
- ▤ INTERLAYERED SAND AND CLAY
- ▥ CLAYEY TO SANDY SILT
- ▨ SANDY TO GRAVELLY CLAY
- ▨ SILTY CLAY TO CLAY

BOREHOLE
SCREEN
BOTTOM OF BOREHOLE

▼ WATER LEVEL IN SHALLOW MONITORING WELL

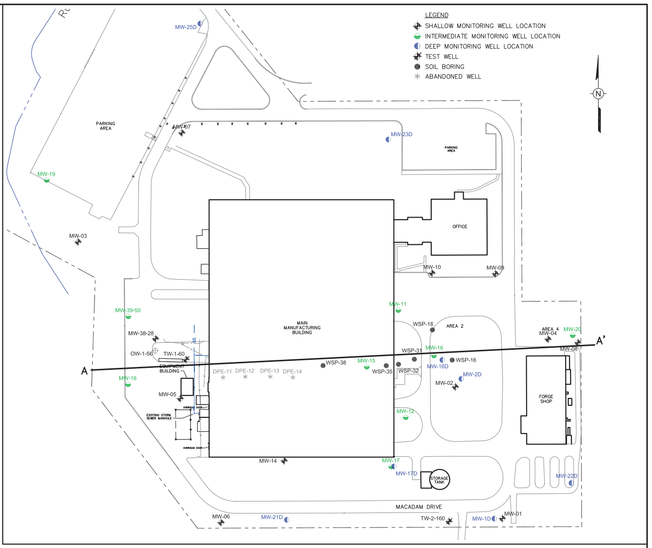
— - - — SHALLOW ZONE GROUNDWATER SURFACE ELEVATION

MW-15 Dec-14	
1,1,1-TCA	20.7
1,1-DCA	71
1,1-DCE	318
1,4-Dioxane	208

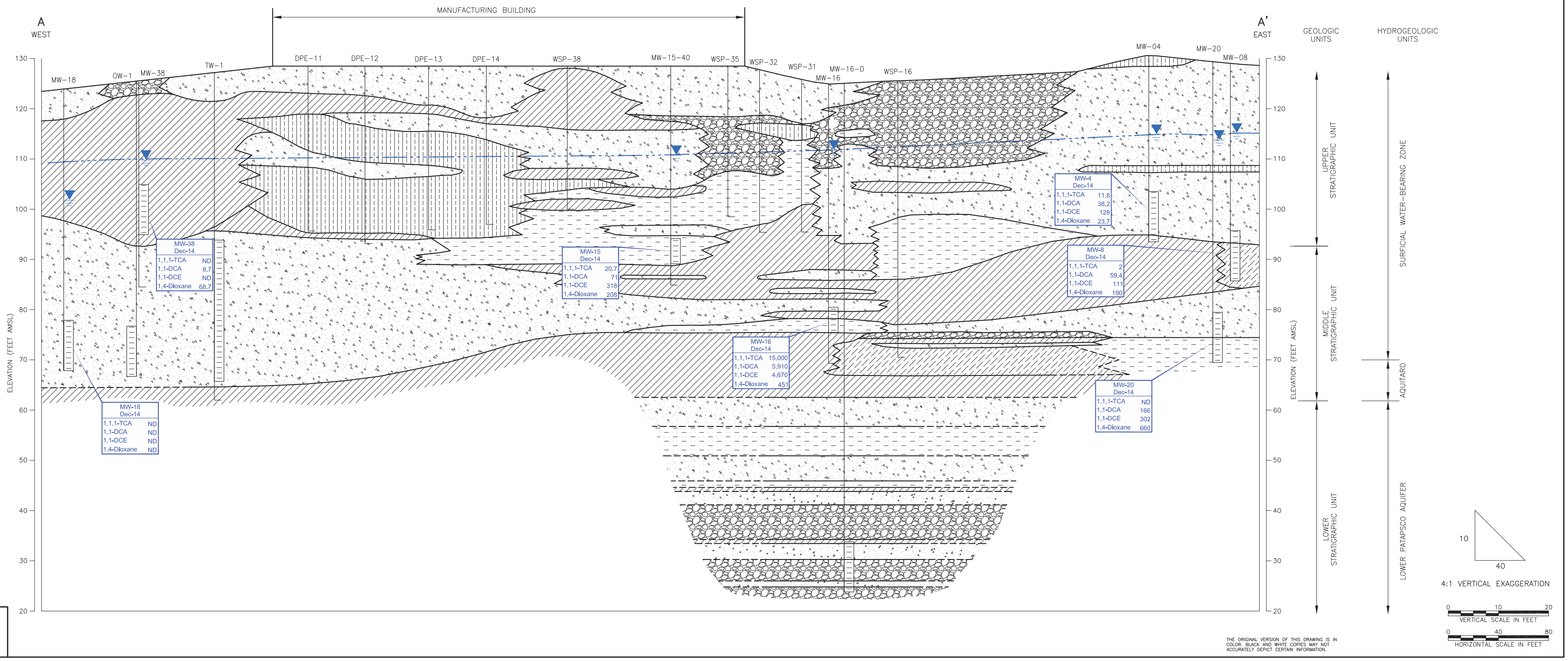
WELL ID
DATE
CONCENTRATION
CONSTITUENT

NOTE:

GROUNDWATER ELEVATIONS FOR SHALLOW AND INTERMEDIATE WELLS FROM DATA COLLECTED IN DECEMBER 2014.



FENCE DIAGRAM LOCATIONS
SCALE: 1"=120'



MW-18 Dec-14	
1,1,1-TCA	ND
1,1-DCA	ND
1,1-DCE	ND
1,4-Dioxane	ND

MW-38 Dec-14	
1,1,1-TCA	ND
1,1-DCA	8.7
1,1-DCE	ND
1,4-Dioxane	68.7

MW-15 Dec-14	
1,1,1-TCA	20.7
1,1-DCA	71
1,1-DCE	318
1,4-Dioxane	208

MW-16 Dec-14	
1,1,1-TCA	15,000
1,1-DCA	5,910
1,1-DCE	4,670
1,4-Dioxane	451

MW-4 Dec-14	
1,1,1-TCA	11.8
1,1-DCA	38.2
1,1-DCE	128
1,4-Dioxane	23.7

MW-8 Dec-14	
1,1,1-TCA	2
1,1-DCA	59.4
1,1-DCE	111
1,4-Dioxane	190

MW-20 Dec-14	
1,1,1-TCA	ND
1,1-DCA	166
1,1-DCE	302
1,4-Dioxane	660

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REVISIONS			
REV	DESCRIPTION		
1	Revised:	Chkd:	Appr.:
2	Revised:	Chkd:	Appr.:
3	Revised:	Chkd:	Appr.:

SEAL

DATE

DRAWN BY	EGC	
CHECKED	MML	4/9/15
APPROVED	RG	

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HYDROGEOLOGIC FENCE DIAGRAM WITH SITE–RELATED VOC CONCENTRATIONS

KOPFLEX FACILITY, INC.
HANOVER, MARYLAND
PREPARED FOR
EMERSON

WSP | PARSONS BRINCKERHOFF

WSP USA Corp.
13530 Dulles Technology Drive, Suite 300
Herndon, Virginia 20171
(703) 709-6500
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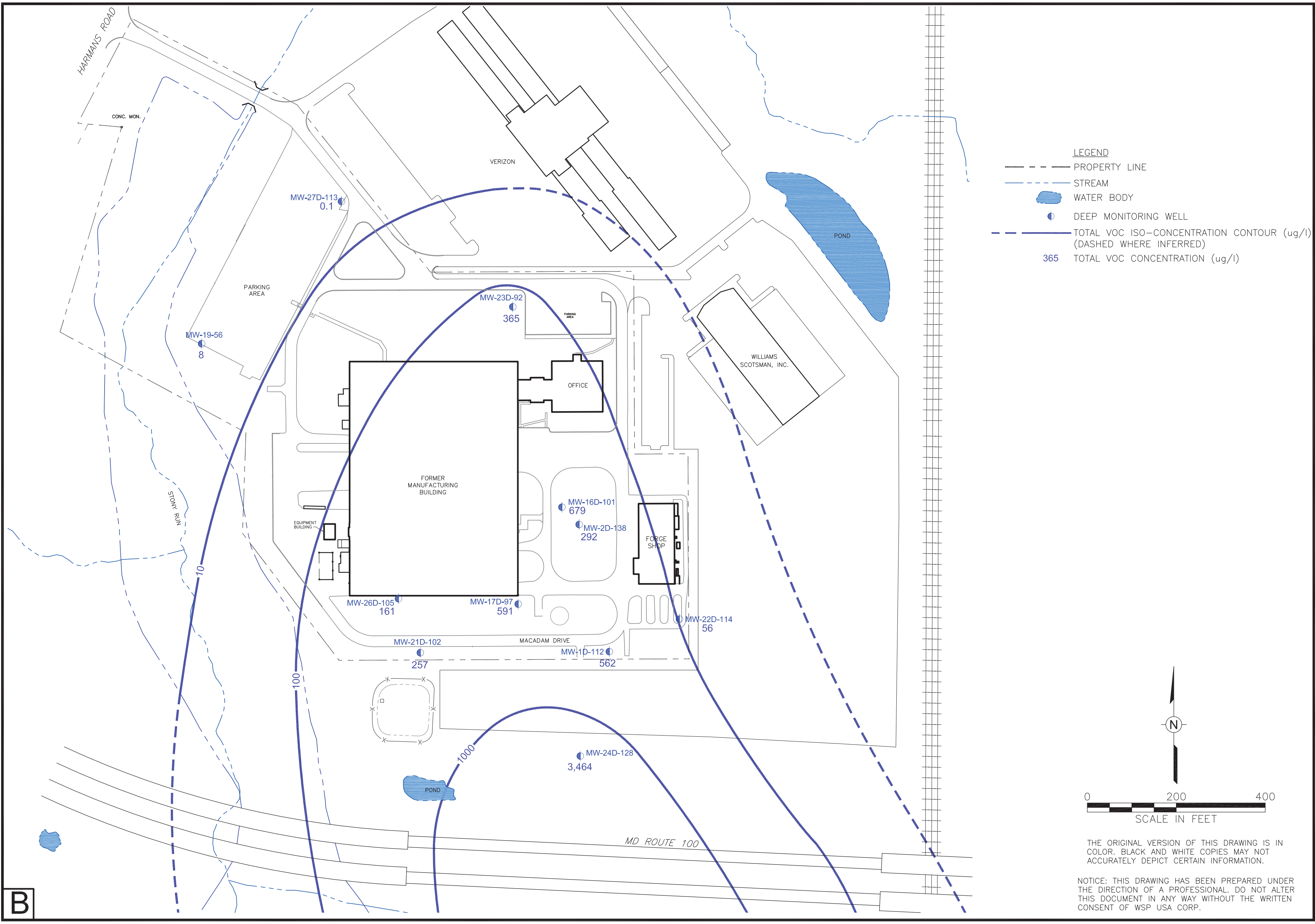
FIGURE 9

Drawing Number
00003705–208



LEGEND

— - —	PROPERTY LINE
- - -	STREAM
▨	WATER BODY
◐	DEEP MONITORING WELL
— —	TOTAL VOC ISO-CONCENTRATION CONTOUR (ug/l) (DASHED WHERE INFERRED)
365	TOTAL VOC CONCENTRATION (ug/l)

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Figure 10

CURRENT SITE LAYOUT WITH TOTAL VOC CONCENTRATIONS IN THE SEMI-CONFINED PORTION OF THE LOWER PATAPSCO AQUIFER (DECEMBER 2014)

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked: MML
Approved: RJ 4/23/2015
DWG Name: 00003705-231

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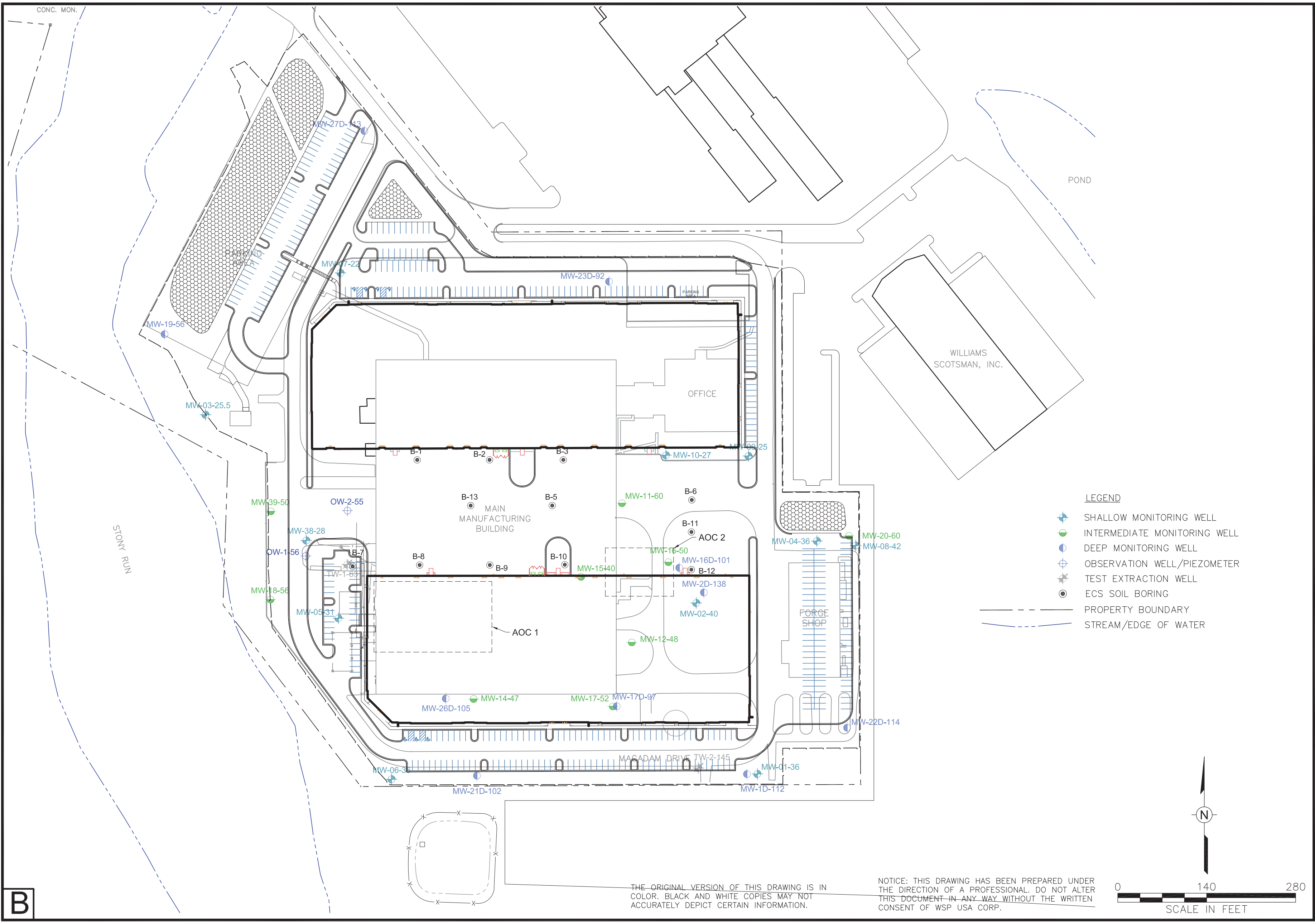

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Figure 11

ECS SOIL BORING LOCATIONS IN THE FUTURE LOADING DOCK AREA (SEPTEMBER 2014)

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: RH 4/23/2015
DWG Name: 00003705-230

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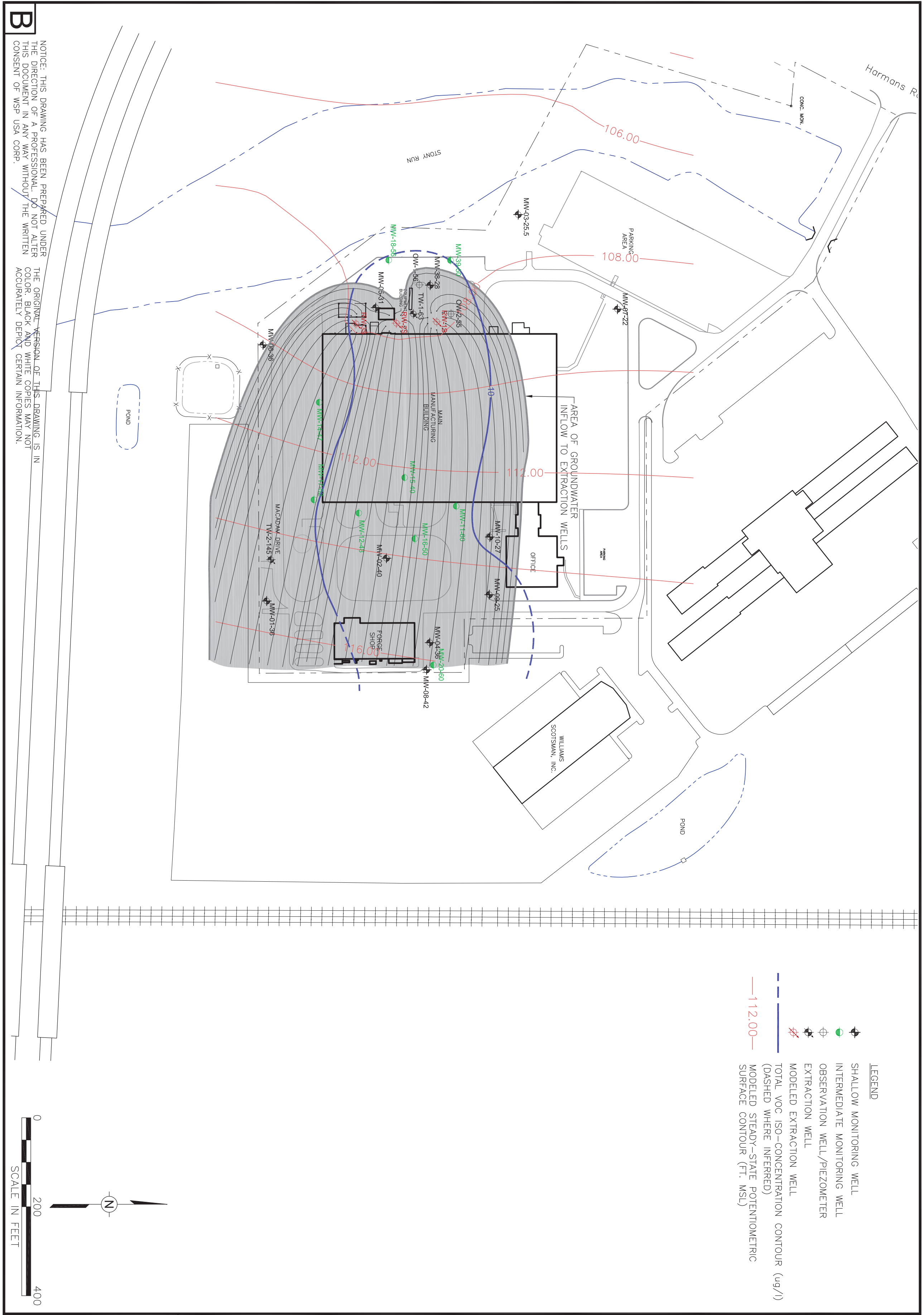

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Figure 12

CURRENT SITE LAYOUT WITH SIMULATED CAPTURE AREA FOR THE UNCONFINED SURFICIAL WATER–BEARING ZONE (INDIVIDUAL WELL DISCHARGE=3 GPM)

FORMER KOP–FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: RG 4/24/2015
DWG Name: 00003705–233

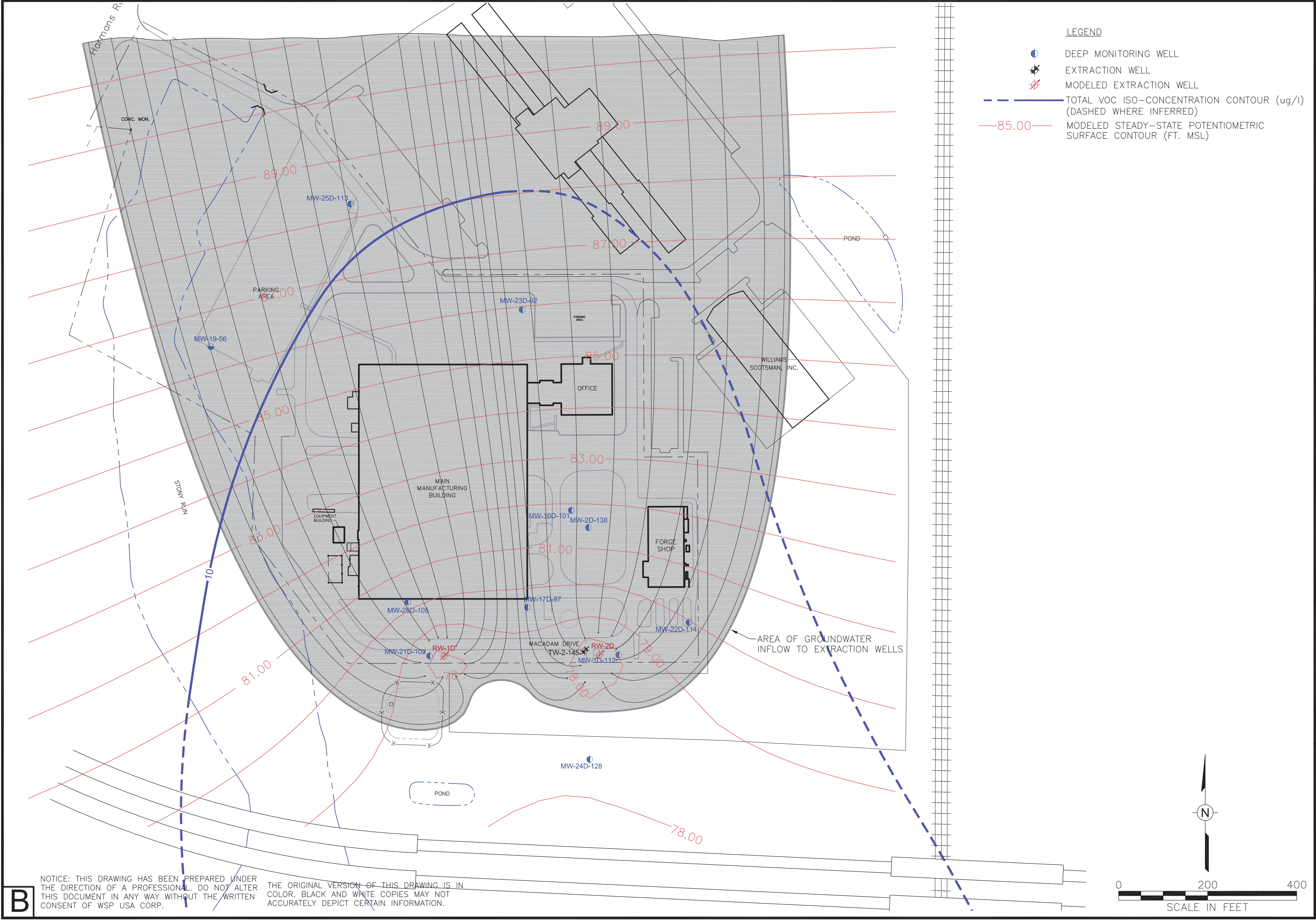

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Figure 13

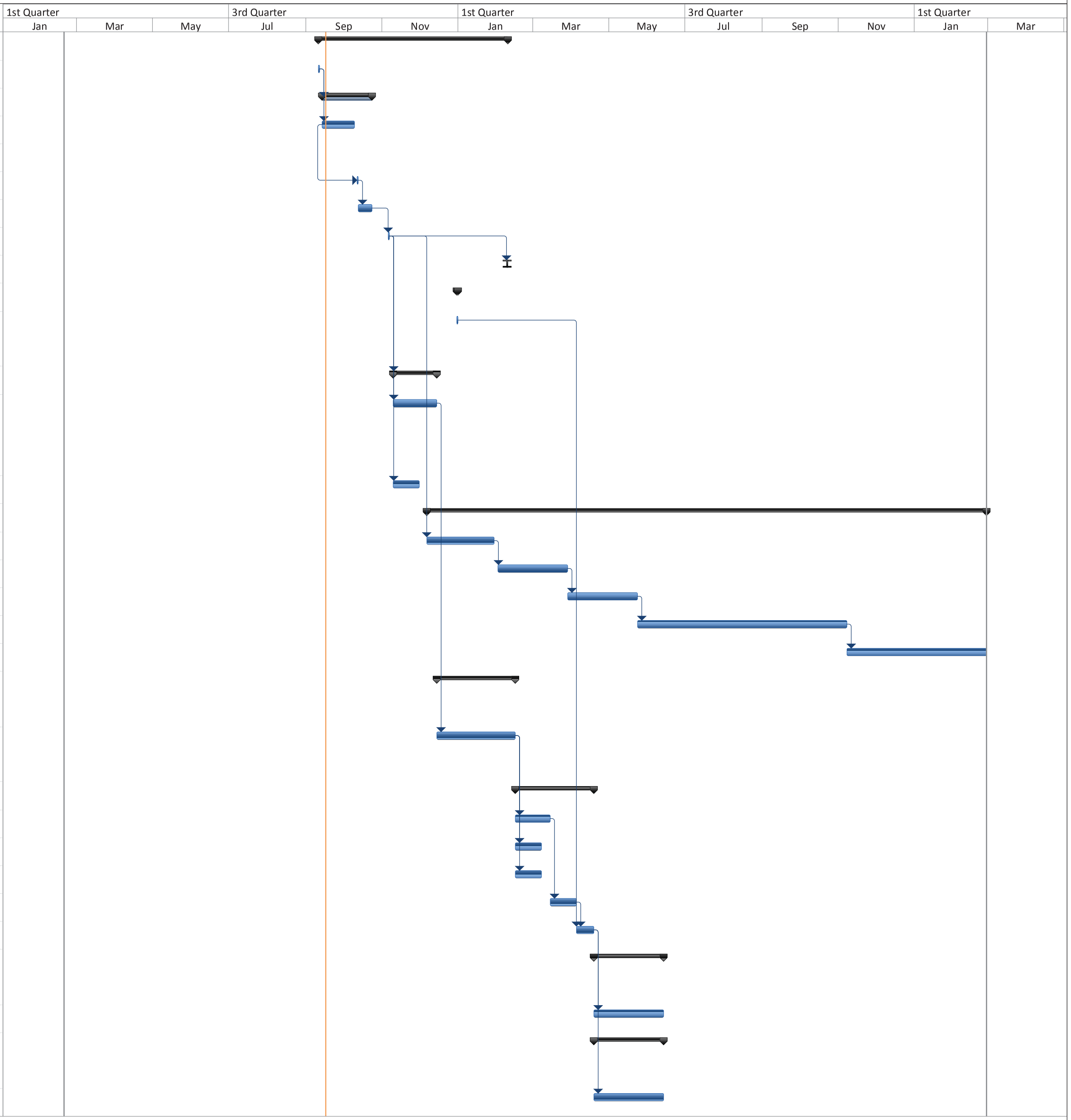
CURRENT SITE LAYOUT WITH SIMULATED CAPTURE AREA FOR THE SEMI-CONFINED PORTION OF THE LOWER PATAPSCO AQUIFER (INDIVIDUAL WELL DISCHARGE=35 GPM)

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: RG 4/24/2015
DWG Name: 00003705-232

Figure 14a
Preliminary Project Implementation Schedule
Former Kop-Flex Property
Hanover, Maryland

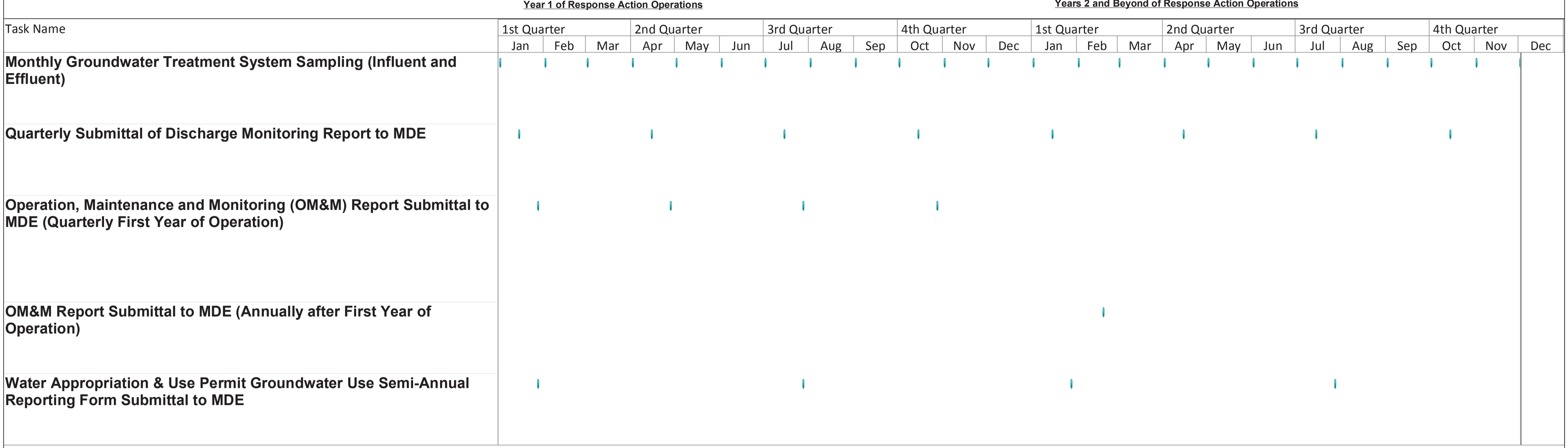
ID	Task Name	Duration	Start	Finish
1	**1. Response Work Plan (RAP)**	**108 days**	**Fri 9/11/15**	**Tue 2/9/16**
2	Submit Plan to MDE	1 day	Fri 9/11/15	Fri 9/11/15
3	**MDE Plan Review (30 Calendar Days)**	**30 days**	**Mon 9/14/15**	**Fri 10/23/15**
4	Public Notification and Comments	20 days	Mon 9/14/15	Fri 10/9/15
5	Public Meeting	1 day	Wed 10/14/15	Wed 10/14/15
6	MDE Plan Formal Review and Comments Letter	1 day	Mon 10/12/15	Mon 10/12/15
7	Response to MDE Comments and Revisions to RAP	9 days	Tue 10/13/15	Fri 10/23/15
8	MDE Approval	1 day	Fri 11/6/15	Fri 11/6/15
9	Update Existing Performance Bond for One Year O&M Costs	1 day	Tue 2/9/16	Tue 2/9/16
10	**2. Water Discharge and Withdrawal Permits**	**1 day**	**Thu 12/31/15**	**Thu 12/31/15**
11	MDE Issuance of NPDES Permit Renewal Application and Water Appropriation and Use Permit Application	1 day	Thu 12/31/15	Thu 12/31/15
12	**3. Groundwater Response Action Design**	**25 days**	**Tue 11/10/15**	**Mon 12/14/15**
13	Electrical Design, Process and Instrumentation Controls Design, Equipment Selection, and Equipment Building Selection	25 days	Tue 11/10/15	Mon 12/14/15
14	Prepare and Submit Health & Safety Plan to MDE	15 days	Tue 11/10/15	Mon 11/30/15
15	**4. Property Redevelopment**	**321 days**	**Mon 12/7/15**	**Mon 2/27/17**
16	Building Demolition	40 days	Mon 12/7/15	Fri 1/29/16
17	Earthwork	40 days	Tue 2/2/16	Mon 3/28/16
18	Vapor Mitigtation System	40 days	Tue 3/29/16	Mon 5/23/16
19	Building Construction	120 days	Tue 5/24/16	Mon 11/7/16
20	Soil Construction Completion Report	80 days	Tue 11/8/16	Mon 2/27/17
21	**5. Groundwater Response Action Bid Solicitation & Contractor Procurement**	**45 days**	**Tue 12/15/15**	**Mon 2/15/16**
22	Earthwork, Well Installation, Electical, Control Panel, Equipment, and Equipment Building	45 days	Tue 12/15/15	Mon 2/15/16
23	**6. Groundwater Response Action Installation & Startup**	**45 days**	**Tue 2/16/16**	**Mon 4/18/16**
24	Equipment and Equipment Building Fabrication	20 days	Tue 2/16/16	Mon 3/14/16
25	Well Installation	15 days	Tue 2/16/16	Mon 3/7/16
26	Earthwork	15 days	Tue 2/16/16	Mon 3/7/16
27	Equipment Delivery and Installation	15 days	Tue 3/15/16	Mon 4/4/16
28	Startup	10 days	Tue 4/5/16	Mon 4/18/16
29	**7. Groundwater Response Action Construction Completion & Implementation Report**	**40 days**	**Tue 4/19/16**	**Mon 6/13/16**
30	Submit Report to MDE	40 days	Tue 4/19/16	Mon 6/13/16
31	**8. Groundwater Response Action Operations & Maintenance Plan**	**40 days**	**Tue 4/19/16**	**Mon 6/13/16**
32	Submit Report to MDE	40 days	Tue 4/19/16	Mon 6/13/16



Note: Schedule is subject to change depending on MDE input and approval. Property redevelopment schedule is subject to change based on developer's schedule.

WSP USA Corp.
Kopflex Schedule

Figure 14b
Preliminary Project Groundwater Treatment System Schedule for Routine Monitoring Activities - Annual Activities
Former Kop-Flex Property
Hanover, Maryland



Note: Schedule is subject to change depending on MDE input and approval. As noted above, the OM&M Report submittals to MDE are quarterly the first year of operation, then annually thereafter.

WSP USA Corp.

20150908_Figure 14b_KopFlex RAP Project Schedule_Ongoing Activities

Tables

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-01-36																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	NA	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	NA	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	NA	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	11.6	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
MW-01D-112																			
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	63	ND	310	NR	ND	430	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	77	6.4	380	NR	ND	422	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	70.9	6.2	389	NR	ND	439.0	ND	NA	ND
	Dec-13 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	45.2	4.40	288	NR	ND	290.0 (l)	ND	NA	ND
	Jun-14 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	45.7	4.70	320	NR	ND	326.0 (c)	ND	NA	ND
	Dec-14 (n)	ND	ND	ND	ND	ND	ND	ND	ND	ND	34.0	4.00	209	NR	ND	279.0 (c)	ND	NA	ND
MW-02-40																			
	May-09	ND	ND	ND	ND	120	ND	ND	ND	ND	1,200	9	600	7	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	17	240	ND	ND	ND	ND	2,900	12	1,200	12	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	3,200	16	1,800	15	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	3,400	15	2,000	13	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	280	ND	ND	ND	ND	3,300	ND	2,200	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	22	130	1	ND	ND	ND	1,600	15	1,800	NR	9	1140	ND	ND	NA
	Jun-12 (d)	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,900	ND	1,900	NR	ND	983	ND	ND	NA
	Dec-12	ND	ND	ND	ND	62	ND	ND	ND	ND	880	10	820	NR	5.8	747	ND	ND	NA
	Jul-13	ND	ND	ND	7	47.6	ND	ND	ND	ND	755	10.3	890	NR	5.6	933.0	ND	NA	ND
	Dec-13 (h)	ND	ND	ND	ND	29	ND	ND	ND	ND	486.0	5.60	457	NR	ND	671.0 (i)	ND	NA	ND
	Jun-14 (h)	ND	ND	ND	ND	28.7	ND	ND	ND	ND	643.0	8.50	678	NR	ND	629.0 (c)	ND	NA	ND
	Dec-14 (h)	ND	ND	ND	ND	29	ND	ND	ND	ND	567	7	528	NR	ND	301 (c)	ND	NA	ND
MW-02D-138																			
	Jul-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	2	120	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	2	130	NR	ND	116	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	130	NR	ND	118	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	2.0	130	NR	ND	101	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	18.5	2.1	170	NR	ND	130.0	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	13.0	1.50	118	NR	ND	109.0 (h)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	19.7	1.80	166	NR	ND	121.0 (n)	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	19.7	1.80	147	NR	ND	103.0 (n)	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-03-25.5																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
MW-04-36																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	350	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	410	3	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	290	8	1,100	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	3	360	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	81	2	200	ND	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	87	2	250	NR	ND	212	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	68	ND	180	NR	ND	158	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	2	210	NR	ND	188	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	108	2.3	233	NR	ND	232.0	ND	ND	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	67.0	1.40	188	NR	ND	178.0 (h)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	1.3	ND	ND	ND	198.0 (c)	7.20	908 (c)	NR	ND	456.0 (h)	ND	NA	ND
	Dec-14 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	38.2	ND	128	NR	ND	23.7	ND	NA	ND
MW-05-31																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	ND	4	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	5	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	7	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	ND	4	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	ND	3	ND	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.1	ND	ND	NR	ND	246	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	ND	ND	NR	ND	211	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.4	ND	ND	NR	ND	245	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.3	ND	2.2	NR	ND	205.0	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.9	ND	1.5	NR	ND	137.0 (h)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.0	ND	1.9	NR	ND	92.3	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.8	ND	1.7	NR	ND	91.2	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-06-36																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
MW-07-22																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	2.4	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	2.2	ND	NA	ND
MW-08-42																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	210	5	250	1	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	260	5	310	1	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	249	5	240	1	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	3	200	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	3	ND	ND	ND	300	6	350	1	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	2	ND	ND	ND	140	3	190	NR	ND	361	ND	ND	NA
	Jun-12 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	150	NR	ND	445	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	4.1	210	NR	ND	418	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	1.1	ND	ND	ND	164	4.4	208	NR	1.2	456.0	ND	ND	ND
	Dec-13	ND	ND	ND	ND	ND	1.2	ND	ND	ND	78.2	2.00	129	NR	ND	254.0 (h)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	89.9	1.90	142	NR	ND	219.0 (h)	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	59.4	1.60	111	NR	ND	190.0	ND	NA	ND
MW-09-25																			
	May-09	ND	ND	ND	ND	ND	1	ND	ND	ND	17	2	250	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	1	ND	ND	ND	18	ND	300	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	2	240	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	2	290	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	1	220	NR	ND	86	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	ND	160	NR	ND	71.3	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	1.2	150	NR	ND	69.2	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	10.9	1.2	170	NR	ND	69.5	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	10.5	1.30	181	NR	ND	97.7 (h)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.5	1.20	193	NR	ND	53.9 (h)	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	11.1	1.40	179	NR	ND	96.1	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-10-27																			
	May-09	ND	ND	ND	ND	ND	6	ND	ND	ND	ND	ND	4	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	ND	4	ND	ND	ND	ND	ND	4	NR	ND	ND	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	3.3	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	NR	ND	ND	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.9	NR	ND	ND	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.9	NR	ND	3.4	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.3	NR	ND	13.1	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.1	NR	ND	2.4	ND	NA	ND
MW-11-60																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	67	9	740	2	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	38	2	ND	ND	ND	620	16	2,100	8	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	10	750	3	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	9	540	2	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	94	8	720	2	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	60	7	430	NR	ND	575	ND	ND	NA
	Jun-12 (h)	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	730	NR	ND	487	ND	ND	NA
	Dec-12	ND	ND	ND	ND	40	1.9	ND	ND	ND	1,000	20	1,800	NR	12	1,160	ND	ND	NA
	Jul-13	ND	ND	ND	ND	11.6	1.4	ND	ND	ND	403	13	1,360	NR	7.2	787.0	ND	NA	ND
	Dec-13 (c)	ND	ND	ND	ND	38.1	ND	ND	ND	ND	742.0	12.80	1,520	NR	10.5	1,000.0	ND	NA	ND
	Jun-14 (m)	ND	ND	ND	ND	ND	ND	ND	ND	ND	75.2	4.90	442	NR	ND	372.0 (c)	ND	NA	ND
	Dec-14 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	190.0	ND	695	NR	ND	397.0 (c)	ND	NA	ND
MW-12-48																			
	May-09	ND	ND	ND	ND	7	2	ND	ND	ND	840	29	2,200	22	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	5	1	ND	ND	ND	680	21	1,900	16	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,100	20	2,300	25	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	610	26	2,200	19	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	11	2	ND	ND	ND	750	34	2,800	24	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	6	3	ND	ND	ND	440	39	2,400	NR	22	1,550	ND	ND	NA
	Jun-12 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	430	ND	1,700	NR	ND	1,130	ND	ND	NA
	Dec-12	ND	ND	ND	ND	30	2.0	ND	ND	ND	460	31	1,600	NR	19	1,240	ND	ND	NA
	Jul-13	ND	ND	ND	ND	152	2.1	ND	ND	ND	869	39.2	2,840	NR	35.2	1,530.0	ND	NA	ND
	Dec-13 (l)	ND	ND	ND	ND	52	ND	ND	ND	ND	439.0	26.20	1,530	NR	ND	1,720.0 (i)	ND	NA	ND
	Jun-14 (c)	ND	ND	ND	ND	83.6	ND	ND	ND	ND	1,210.0	43.50	3,510	NR	33.2	182.0 (n)	ND	NA	ND
	Dec-14 (i)	ND	ND	ND	ND	145.0	ND	ND	ND	ND	1,370.0	37.50	3,350	NR	34.8	1,270.0 (n)	ND	NA	ND
MW-14-47																			
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NA	ND	ND	NA
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	NR	NA	ND	ND	NA
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.8	NR	ND	6.9	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	NR	ND	7.4	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	3.6	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.6	NR	ND	3.0	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2	NR	ND	3.3	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	2.2	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-15-40																			
	Sep-10	ND	ND	ND	ND	4	1	ND	ND	ND	370	16	1,300	9	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	9	670	5	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	8	ND	ND	ND	ND	210	3	300	2	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	ND	4	ND	ND	ND	ND	190	7	530	NR	3	345	ND	ND	NA
	Jun-12 (h)	ND	ND	ND	ND	ND	ND	ND	ND	ND	200	ND	500	NR	ND	575	ND	ND	NA
	Dec-12	ND	ND	ND	ND	11	ND	ND	ND	ND	320	5.2	540	NR	4.2	272	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	153	ND	465	NR	5.5	2,530.0	ND	NA	ND
	Dec-13 (g)	ND	ND	ND	ND	3	ND	ND	ND	ND	181.0	3.00	289	NR	2.8	228.0 (h)	ND	NA	ND
	Jun-14 (n)	ND	ND	ND	ND	ND	ND	ND	ND	ND	57.0	4.40	433 (c)	NR	5.8	92.8 (g)	ND	NA	ND
	Dec-14 (m)	ND	ND	ND	ND	ND	ND	ND	ND	ND	71.0	ND	318	NR	ND	208.0 (n)	ND	NA	ND
MW-16-50																			
	Sep-10	ND	ND	ND	23	480	13	6	3	ND	8,300	57	16,000	67	NR	NA	22	10	NA
	Oct-10	ND	ND	ND				ND	ND	ND	4,900	42	12,000	52	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	660	ND	ND	ND	ND	3,400	ND	19,000	ND	NR	NA	ND	ND	NA
	Dec-11	ND	ND	ND	23	560	7	ND	1.7	ND	8,200	53	18,000	NR	59	1,930	12	4.6	NA
	Jun-12 (f)	ND	ND	ND	ND	ND	ND	ND	ND	ND	4,300	ND	11,000	NR	ND	2,050	ND	ND	NA
	Dec-12	ND	ND	ND	18	460	5.8	ND	1.3	1.1	14,000	52	14,000	NR	56	1,740	7.6	3.3	NA
	Jul-13	46.5	ND	1.8	ND	1,290	7.2	2.7	1.4	ND	3,600	61.3	17,900	NR	59.1	2,260.0	9.9	NA	ND
	Dec-13 (k)	ND	ND	ND	ND	266	ND	ND	ND	ND	2,050.0	ND	19,400	NR	ND	2,840.0 (d)	ND	NA	ND
	Jun-14 (k)	ND	ND	ND	ND	278	ND	ND	ND	ND	3,850.0	ND	16,400	NR	ND	1,570.0 (i)	ND	NA	ND
	Dec-14	ND	ND	ND	17	ND	2.2	ND	ND	ND	5,910.0 (p)	18.90	4,670 (p)	NR	32.6	451.0 (h)	4	NA	2
MW-16D-101																			
	Jan-11	ND	ND	ND	ND	3	4	ND	ND	ND	110	4	330	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	4	400	ND	NR	NA	ND	ND	NA
	Dec-11	ND	2	ND	ND	ND	ND	ND	ND	ND	72	4	240	NR	ND	267	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	49	ND	150	NR	ND	215	ND	ND	NA
	Dec-12	ND	1.3	ND	ND	ND	ND	ND	ND	ND	55	3	130	NR	ND	189	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	54.3	3	193	NR	ND	246.0	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	43.2	2.20	155	NR	ND	218.0 (h)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	57.6	3.50	191	NR	ND	232.0 (h)	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	90.0	4.10 (n)	288	NR	ND	251.0 (h)	ND	NA	ND
MW-17-52																			
	Sep-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	7	ND	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	5	ND	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	2	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	1	ND	ND	ND	ND	46	ND	41	NR	ND	22	ND	ND	NA
	Jun-12 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	10.2	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	4.4	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6	NR	ND	4.3	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	NR	ND	34.3	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	2.5	ND	NA	ND
MW-17D-97																			
	Sep-10	ND	ND	ND	ND	4	1	ND	ND	ND	150	12	940	7	NR	NA	ND	ND	NA
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	190	13	1,300	9	NR	NA	ND	ND	NA
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	290	ND	2,100	ND	NR	NA	ND	ND	NA
	Nov-11	ND	ND	ND	ND	15	1	ND	ND	ND	270	14	1,900	NR	14	575	ND	ND	NA
	Jun-12 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	290	ND	1,000	NR	ND	618	ND	ND	NA
	Dec-12	ND	ND	ND	ND	41	1.3	ND	ND	ND	470	17	1,800	NR	19	669	ND	ND	NA
	Jul-13	ND	ND	ND	ND	68.4	1.3	ND	ND	ND	496	17	2,310	NR	22.3	612.0	ND	NA	ND
	Dec-13 (m)	ND	ND	ND	ND	37	ND	ND	ND	ND	326.0	13.60	2,100	NR	16.8	592.0 (l)	ND	NA	ND
	Jun-14 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	143.0	10.20	1,260	NR	ND	435.0	ND	NA	ND
	Dec-14	ND	ND	ND	ND	2	ND	ND	ND	ND	66.2	4.60	484	NR	3.8	23.3	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-18-56																			
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	13.6	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	4.6	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
MW-19-56																			
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	NR	ND	5.9	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	4.0	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	3.6	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6	NR	ND	5.5	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.5	NR	ND	4.1	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.7	NR	ND	6.3	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.0	NR	ND	4.2	ND	NA	ND
MW-20-60																			
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	11.9	ND	ND	NA
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.5	ND	51	NR	ND	272	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	3.1	120	NR	ND	506	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	83.8	6.2	255	NR	1.5	845.0	ND	NA	ND
	Dec-13 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	121.0	7.00	333	NR	ND	1,230.0 (i)	ND	NA	ND
	Jun-14 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	173.0	8.80	359	NR	2.1	1,010.0 (i)	ND	NA	ND
	Dec-14 (m)	ND	ND	ND	ND	ND	ND	ND	ND	ND	166.0	9.30	302	NR	ND	660.0 (i)	ND	NA	ND
MW-21D-102																			
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	90	NR	ND	84.2	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	90	NR	ND	81.8	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	11.9	ND	102	NR	ND	80.1	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	10.1	ND	82.4	NR	ND	70.0	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.3	ND	76.5	NR	ND	77.0 (g)	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	10.4	ND	105.0	NR	ND	138.0	ND	NA	ND
MW-22D-114																			
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	27	NR	ND	29	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.5	ND	38	NR	ND	41	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.7	ND	34.2	NR	ND	31.8	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.7	ND	43.5	NR	ND	35.3 (g)	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.5	ND	44.2	NR	ND	39.3	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	ND	27.0	NR	ND	22.8	ND	NA	ND
MW-23D-92																			
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	29	ND	120	NR	ND	149	ND	ND	NA
	Aug-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	39	2.2	130	NR	ND	NA	ND	ND	NA
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	32	2.0	110	NR	ND	130	ND	ND	NA
	Jul-13	ND	ND	ND	ND	ND	ND	1.5	ND	ND	32.7	2.3	131	NR	ND	186.0	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	25.6	1.7	101	NR	ND	165.0 (h)	ND	ND	ND
	Jun-14	ND	1.2	ND	ND	ND	ND	ND	ND	ND	29.1	2.3	101	NR	ND	132.0 (g)	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	28.3	1.90	157.0	NR	ND	151.0	ND	NA	ND
MW-27D-113																			
	Sep-13	ND	ND	ND	ND	ND	2.1	ND	ND	ND	ND	0.17 J	ND	NR	ND	0.9 J	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Acetone	Benzene	Bromoform	2-Butanone (MEK)	Chloroethane	Chloroform	Chloromethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethene	cis-1,2-Dichloroethene	1,4- Dioxane	Ethylbenzene	Isopropylbenzene	p-Isopropyltoluene
MW-26D-105																			
	Mar-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	12.4	ND	98.2	NR	ND	118.0	ND	NA	ND
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	13.5	ND	120	NR	ND	99.2	ND	NA	ND
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.9	ND	51.5	NR	ND	60.7	ND	NA	ND
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.2	ND	42.4	NR	ND	39.8	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.5	ND	78	NR	ND	73.0	ND	NA	ND
MW-38-28																			
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.5	ND	ND	NR	ND	51.8	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.7	ND	ND	NR	ND	68.7	ND	NA	ND
MW-39-50																			
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.2	NR	ND	6.3	ND	NA	ND
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND	ND	NA	ND

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-01-36												
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
MW-01D-112												
	Jun-12	ND	ND	ND	ND	ND	96	ND	ND	ND	ND	899
	Dec-12	ND	ND	ND	ND	ND	120	1.6	1.7	ND	ND	1,009
	Jul-13	ND	ND	ND	ND	ND	98.8	1.5	1.8	ND	ND	1,007
	Dec-13 (g)	ND	ND	ND	ND	ND	62.4	ND	ND	ND	ND	690
	Jun-14 (g)	ND	ND	ND	ND	ND	62.4	ND	ND	ND	ND	759
	Dec-14 (n)	ND	ND	ND	ND	ND	35.8	ND	ND	ND	ND	562
MW-02-40												
	May-09	3	ND	ND	3	ND	150	ND	8	2	ND	2,102
	Oct-09	5	ND	ND	7	ND	380	ND	17	4	3	4,797
	May-10	ND	ND	ND	11	ND	520	ND	22	5	ND	5,589
	Oct-10	ND	ND	ND	11	ND	2,700	ND	23	4	ND	8,166
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5,780
	Nov-11	4.4	ND	ND	8	ND	2,800	1	22	6	3.3	7,561
	Jun-12 (d)	ND	ND	ND	ND	ND	6,100	ND	ND	ND	ND	10,883
	Dec-12	ND	ND	ND	3.6	ND	350	ND	11	ND	ND	2,889
	Jul-13	ND	ND	ND	4	ND	541	ND	11.7	2.8	ND	3,208
	Dec-13 (h)	ND	ND	ND	ND	ND	228.0	ND	5.7	ND	ND	1,882
	Jun-14 (h)	16.3	ND	ND	ND	ND	599.0	ND	11.2	ND	ND	2,614
	Dec-14 (h)	ND	ND	ND	ND	ND	21	ND	6	ND	ND	1,459
MW-02D-138												
	Jul-11	ND	ND	ND	ND	ND	28	ND	ND	ND	ND	166
	Nov-11	ND	ND	ND	ND	ND	27	ND	ND	ND	ND	292
	Jun-12	ND	ND	ND	ND	ND	28	ND	ND	ND	ND	292
	Dec-12	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	273
	Jul-13	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	344
	Dec-13	ND	ND	ND	ND	ND	15.9	ND	ND	ND	ND	257
	Jun-14	ND	ND	ND	ND	ND	26.9	ND	ND	ND	ND	335
	Dec-14	ND	ND	ND	ND	ND	20.2	ND	ND	ND	ND	292

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-03-25.5												
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
MW-04-36												
	May-09	ND	ND	ND	1	ND	100	ND	3	ND	ND	584
	Oct-09	ND	ND	ND	1	ND	100	ND	3	ND	ND	667
	May-10	ND	ND	ND	5	ND	180	ND	8	ND	ND	1,591
	Oct-10	ND	ND	ND	2	ND	75	ND	3	ND	ND	573
	Jun-11	ND	ND	ND	ND	ND	32	ND	2	ND	ND	317
	Dec-11	ND	ND	ND	ND	ND	47	ND	2	ND	ND	600
	Jun-12	ND	ND	ND	ND	ND	25	ND	ND	ND	ND	431
	Dec-12	ND	ND	ND	ND	ND	26	ND	2	ND	ND	528
	Jul-13	ND	ND	ND	ND	ND	27.9	ND	2.3	ND	ND	606
	Dec-13	ND	ND	ND	ND	ND	21.3	ND	1.7	ND	ND	457
	Jun-14	ND	ND	ND	3.2	ND	104.0	ND	8.0	ND	ND	1,686
	Dec-14 (g)	ND	ND	ND	ND	ND	11.8	ND	ND	ND	ND	202
MW-05-31												
	May-09	ND	ND	ND	ND	ND	6	ND	ND	ND	ND	19
	Oct-09	ND	ND	ND	ND	ND	6	ND	ND	ND	ND	22
	May-10	ND	ND	ND	ND	ND	6	ND	ND	ND	ND	25
	Oct-10	ND	ND	ND	ND	ND	5	ND	ND	ND	ND	17
	Jun-11	ND	ND	ND	ND	ND	5	ND	ND	ND	ND	15
	Dec-11	ND	ND	ND	ND	ND	4	ND	ND	ND	ND	255
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	218
	Dec-12	ND	ND	ND	ND	ND	2.2	ND	ND	ND	ND	251
	Jul-13	ND	ND	ND	ND	ND	2.4	ND	ND	ND	ND	213
	Dec-13	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	143
	Jun-14	ND	ND	ND	ND	ND	2.5	ND	ND	ND	ND	100
	Dec-14	ND	ND	ND	ND	ND	2.0	ND	ND	ND	ND	98

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-06-36												
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
MW-07-22												
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
MW-08-42												
	May-09	ND	ND	ND	1	ND	100	ND	4	ND	ND	571
	Oct-09	ND	ND	ND	1	ND	70	ND	4	ND	ND	651
	May-10	ND	ND	ND	2	ND	65	ND	4	ND	ND	566
	Oct-10	ND	ND	ND	ND	ND	25	ND	3	ND	ND	401
	Jun-11	ND	ND	ND	1	ND	23	ND	4	ND	ND	688
	Dec-11	ND	ND	ND	ND	ND	13	ND	2	ND	ND	711
	Jun-12 (g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	735
	Dec-12	ND	ND	ND	ND	ND	9.0	ND	3.1	ND	ND	824
	Jul-13	ND	ND	ND	1.1	ND	6.4	ND	3.6	ND	ND	846
	Dec-13	ND	ND	ND	ND	ND	4.7	ND	1.8	ND	ND	471
	Jun-14	ND	ND	ND	ND	ND	3.3	ND	1.6	ND	ND	458
	Dec-14	ND	ND	ND	ND	ND	2.0	ND	1.3	ND	ND	365
MW-09-25												
	May-09	ND	ND	ND	ND	ND	16	ND	ND	ND	ND	286
	Oct-09	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	332
	May-10	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	268
	Jun-11	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	318
	Nov-11	ND	ND	ND	ND	ND	8	ND	ND	ND	ND	330
	Jun-12	ND	ND	ND	ND	ND	6	ND	ND	ND	ND	245
	Dec-12	ND	ND	ND	ND	ND	5.5	ND	ND	ND	ND	238
	Jul-13	ND	ND	ND	ND	ND	6.4	ND	ND	ND	ND	258
	Dec-13	ND	ND	ND	ND	ND	4.6	ND	ND	ND	ND	295
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	257
	Dec-14	ND	ND	ND	ND	ND	9.4	ND	ND	ND	ND	297

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-10-27												
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
MW-11-60												
	May-09	ND	ND	ND	ND	ND	47	ND	4	ND	ND	869
	Oct-09	4	ND	ND	3	ND	230	2	13	1	ND	3,037
	May-10	ND	ND	ND	ND	ND	67	ND	5	ND	ND	965
	Oct-10	ND	ND	ND	ND	ND	52	ND	5	ND	ND	718
	Jun-11	ND	ND	ND	ND	ND	29	ND	3	ND	ND	856
	Dec-11	ND	ND	ND	ND	ND	16	ND	ND	ND	ND	1,088
	Jun-12 (h)	ND	ND	ND	ND	ND	35	ND	ND	ND	ND	1,382
	Dec-12	6.7	ND	ND	4	ND	300	2.9	13	ND	ND	4,360
	Jul-13	ND	ND	ND	1.6	ND	103	1	8.8	1.6	ND	2,699
	Dec-13 (c)	ND	ND	ND	ND	ND	343.0	ND	10.3	ND	ND	3,677
	Jun-14 (m)	9	ND	ND	ND	ND	21.7	ND	ND	ND	ND	925
	Dec-14 (c)	ND	ND	ND	ND	ND	28.8	ND	ND	ND	ND	1,311
MW-12-48												
	May-09	3	ND	ND	4	ND	120	3	16	2	ND	3,248
	Oct-09	2	ND	ND	3	ND	87	2	13	2	ND	2,732
	May-10	ND	ND	ND	4	ND	160	ND	9	3	ND	3,621
	Oct-10		ND	ND	3	ND	110	2	13	2	ND	2,985
	Jun-11	3	ND	ND	3	ND	110	3	16	2	ND	3,758
	Nov-11	2	ND	ND	3	ND	85	4	17	2	ND	4,573
	Jun-12 (c)	ND	ND	ND	ND	ND	63	ND	ND	ND	ND	3,323
	Dec-12	ND	ND	ND	2.0	ND	48	3.3	13	ND	ND	3,448
	Jul-13	6.6	ND	ND	4	ND	77.2	3.2	16.7	2.6	ND	5,578
	Dec-13 (l)	ND	ND	ND	ND	ND	41.8	ND	ND	ND	ND	3,809
	Jun-14 (c)	ND	ND	ND	ND	ND	125.0	ND	17.8	ND	ND	5,205
	Dec-14 (i)	ND	ND	ND	ND	ND	78.8	ND	ND	ND	ND	6,286
MW-14-47												
	May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Oct-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
	May-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
	Oct-10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
	Nov-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-15-40												
	Sep-10	ND	ND	ND	4	ND	27	2	15	1	ND	1,749
	Oct-10	ND	ND	ND	2	ND	22	2	7	ND	ND	897
	Jun-11	ND	ND	ND	ND	ND	51	ND	2	ND	ND	576
	Dec-11	ND	ND	ND	1	ND	48	ND	4.7	ND	ND	1,133
	Jun-12 (h)	ND	ND	ND	ND	ND	47	ND	ND	ND	ND	1,322
	Dec-12	ND	ND	ND	1.2	ND	150	ND	5.2	ND	ND	1,309
	Jul-13	ND	ND	ND	ND	ND	43.2	ND	ND	ND	ND	3,197
	Dec-13 (g)	ND	ND	ND	ND	ND	107.0	ND	2.4	ND	ND	817
	Jun-14 (n)	10.2	ND	ND	ND	ND	13.7	ND	ND	ND	ND	617
	Dec-14 (m)	ND	ND	ND	ND	ND	20.7	ND	ND	ND	ND	618
MW-16-50												
	Sep-10	28	ND	17	250	7	160,000	4	370	ND	101	185,758
	Oct-10	ND	ND	ND	140	ND	71,000	3	190	6	ND	88,333
	Jun-11	ND	ND	ND	ND	ND	21,000	ND	130	ND	ND	44,190
	Dec-11	30	ND	7.1	110	4.2	100,000	3	220	14	57	129,295
	Jun-12 (f)	ND	ND	ND	ND	ND	41,000	ND	ND	ND	ND	58,350
	Dec-12	30	ND	4.5	69	3.4	30,000	3.5	160	9.2	36	60,661
	Jul-13	29.5	ND	6	83.8	4.4	29,400	4.3	ND	17.7	46.2	54,832
	Dec-13 (k)	ND	ND	ND	ND	ND	12,000.0	ND	ND	ND	ND	36,556
	Jun-14 (k)	ND	ND	ND	ND	ND	30,500.0	ND	213.0	ND	ND	52,811
	Dec-14	7	ND	3	30.7	1.6	15,000.0 (p)	ND	63.8	5.1	17	26,236
MW-16D-101												
	Jan-11	8	ND	2	ND	ND	82	ND	2	ND	3	548
	Jun-11	ND	ND	ND	ND	ND	75	ND	2	ND	ND	581
	Dec-11	ND	ND	ND	ND	ND	64	ND	1	ND	ND	650
	Jun-12	ND	ND	ND	ND	ND	33	ND	ND	ND	ND	447
	Dec-12	ND	ND	ND	ND	ND	29	ND	ND	ND	ND	407
	Jul-13	ND	ND	ND	ND	ND	23.8	ND	ND	ND	ND	520
	Dec-13	ND	ND	ND	ND	ND	21.3	ND	ND	ND	ND	440
	Jun-14	ND	ND	ND	ND	ND	28.9	ND	ND	ND	ND	513
	Dec-14	ND	ND	ND	ND	ND	44.3	ND	1.8	ND	ND	679
MW-17-52												
	Sep-10	ND	ND	ND	ND	ND	7	ND	ND	ND	ND	24
	Oct-10	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	10
	Jun-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Nov-11	ND	ND	ND	ND	ND	22	ND	ND	ND	ND	132
	Jun-12 (c)	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	33
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	37
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
MW-17D-97												
	Sep-10	5	ND	ND	1	ND	26	ND	9	1	ND	1,156
	Oct-10	ND	ND	ND	2	ND	42	ND	10	ND	ND	1,566
	Jun-11	ND	ND	ND	ND	ND	29	ND	ND	ND	ND	2,419
	Nov-11	3	ND	ND	3	ND	38	2	12	ND	ND	2,847
	Jun-12 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,908
	Dec-12	4.7	ND	ND	1.5	ND	36.0	ND	11	ND	ND	3,071
	Jul-13	6.6	ND	ND	2	ND	36.2	ND	10.9	1.5	ND	3,584
	Dec-13 (m)	ND	ND	ND	ND	ND	22.6	ND	7.9	ND	ND	3,116
	Jun-14 (c)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,848
	Dec-14	ND	ND	ND	ND	ND	4.3	ND	2.9	ND	ND	591

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-18-56												
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
MW-19-56												
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
	Jul-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12
	Dec-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
MW-20-60												
	Dec-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12
	Jun-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	332
	Dec-12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	659
	Jul-13	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	1,194
	Dec-13 (g)	ND	ND	ND	ND	ND	ND	2.5	ND	ND	ND	1,694
	Jun-14 (g)	5.6	ND	ND	ND	ND	ND	3.3	2.1	ND	ND	1,564
	Dec-14 (m)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,137
MW-21D-102												
	Jun-12	ND	ND	ND	ND	ND	8	ND	ND	ND	ND	194
	Dec-12	ND	ND	ND	ND	ND	5.7	ND	ND	ND	ND	192
	Jul-13	ND	ND	ND	ND	ND	5	ND	ND	ND	ND	199
	Dec-13	ND	ND	ND	ND	ND	4.1	ND	ND	ND	ND	167
	Jun-14	ND	ND	ND	ND	ND	2.8	ND	ND	ND	ND	165
	Dec-14	ND	ND	ND	ND	ND	3.2	ND	ND	ND	ND	257
MW-22D-114												
	Jun-12	ND	ND	ND	ND	ND	8	ND	ND	ND	ND	64
	Dec-12	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	94
	Jul-13	ND	ND	ND	ND	ND	6.5	ND	ND	ND	ND	75
	Dec-13	ND	ND	ND	ND	ND	8.4	ND	ND	ND	ND	91
	Jun-14	ND	ND	ND	ND	ND	9.0	ND	ND	ND	ND	96
	Dec-14	ND	ND	ND	ND	ND	4.2	ND	ND	ND	ND	56
MW-23D-92												
	Jun-12	ND	ND	ND	ND	ND	36	ND	ND	ND	ND	334
	Aug-12	ND	ND	ND	ND	ND	35	ND	ND	ND	ND	206
	Dec-12	ND	ND	ND	ND	ND	31	ND	ND	ND	ND	305
	Jul-13	ND	ND	ND	ND	ND	28.6	ND	ND	ND	ND	382
	Dec-13	ND	ND	ND	ND	ND	21.3	ND	ND	ND	ND	315
	Jun-14	ND	ND	ND	ND	ND	24.7	ND	ND	ND	ND	290
	Dec-14	ND	ND	ND	ND	ND	26.5	ND	ND	ND	ND	365
MW-27D-113												
	Sep-13	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND	4
	Dec-13	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	1
	Jun-14	ND	1.6	ND	ND	ND	ND	ND	ND	ND	ND	2
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---

Table 1

Summary of COCs Detected in Groundwater Samples (2009 - 2014)
On-Property Monitoring Wells
Former Kop-Flex Facility
Hanover, Maryland (a)

Monitoring Well		Methylene Chloride	Methyl-tert-butyl Ether	Naphthalene	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethene	Vinyl Chloride	Xylene (total)	Total Detected VOCs
MW-26D-105												
	Mar-13	ND	ND	ND	ND	5.6	6.3	ND	ND	ND	ND	241
	Jul-13	ND	ND	ND	ND	ND	6.6	ND	ND	ND	ND	239
	Dec-13	ND	ND	ND	ND	ND	2.7	ND	ND	ND	ND	122
	Jun-14	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	89
	Dec-14	ND	ND	ND	ND	ND	2.8	ND	ND	ND	ND	161
MW-38-28												
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	61
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	77
MW-39-50												
	Jun-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10
	Dec-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---

a/ all samples measured in ppb (ug/L);
E = result exceeds calibration range
ND = not detected; NA = Not analyzed
NR = not reported
b/suspected laboratory contaminant
c/ sample run at a 10x dilution
d/ sample run at 50x dilution
e/ estimated below the detection limit;
f/sample run at a 250x dilution
g/sample run at a 2x dilution
h/sample run at a 5x dilution
i/sample run at a 25x dilution
k/sample run at 200x dilution
l/sample run at 20x dilution
m/sample run at 4x dilution
n/sample run at 2.5x dilution
p/sample run at 400x dilution

Table 2

Soil Sample Results, Proposed Loading Dock Area
Former Kop-Flex Facility
Hanover, MD
September 2014 (a)

Analyte	Sample ID Date Collected Sample Depth (ft)	B-1 25-Sep-14 3-4		B-2 25-Sep-14 2-3		B-3 25-Sep-14 3-4		B-4 25-Sep-14 3-4		B-5 25-Sep-14 1-2		B-6 25-Sep-14 2-3		B-7 25-Sep-14 4-5		B-8 25-Sep-14 4-5		B-9 25-Sep-14 3-4		B-10 25-Sep-14 2-3	
Volatile Organic Compounds (mg/kg)	**MDE Residential Soil Cleanup Standard (mg/kg)**																				
Carbon Disulfide	780	0.0053	U	0.0049	U	0.0057	U	0.0043	U	0.0028	J	0.0055	U	0.0051	U	0.0033		0.0055	U	0.0046	U
1,1,1-Trichloroethane	16,000	0.0053	U	0.0049	U	0.0057	U	0.0043	U	0.0056	U	0.0084		0.0051	U	0.0054	U	0.0055	U	0.0046	U
Polycyclic Aromatic Hydrocarbons (mg/kg)																					
Fluoranthene	310	0.01	U	0.01	U	0.01	U	0.0163		0.01	U	0.0105	U	0.0111	U	0.0106	U	0.0102	U	0.0355	
Phenanthrene	2,300	0.01	U	0.01	U	0.01	U	0.0158		0.01	U	0.0105	U	0.0111	U	0.0106	U	0.0102	U	0.108	U
Pyrene	230	0.01	U	0.01	U	0.01	U	0.0102	U	0.01	U	0.0105	U	0.0111	U	0.0106	U	0.0102	U	0.0199	
Gasoline Range Organics (mg/kg)																					
Gasoline Range Organics	230	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.11	U	0.11	U	0.11	U	0.1	U	0.11	U
Diesel Range Organics (mg/kg)																					
Diesel Range Organics	230	8	U	8	U	8	U	8	U	8	U	8.4	U	8.9	U	8.5	U	8.2	U	8.6	U
Polychlorinated Biphenyls (mg/kg)																					
Total Polychlorinated Biphenyls	NA	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND	
Total Metals Analysis (mg/kg)																					
Arsenic	3.6 (c)	1.79		2.19		0.605		0.527		1.21		1.15		1.73		5.3		6.06		2.37	
Barium	1,600	9		2.73		1.27		3.03		2.39		7.55		6.54		7.42		1.63		3.32	
Cadmium	3.9	0.414	Ub	0.388	Ub	0.401	Ub	0.411	Ub	0.397	Ub	0.412	Ub	0.411	Ub	0.401	Ub	0.342	Ub	0.426	Ub
Chromium	23	10.3		2.08		1.75		2.9		2		3.89		6.14		13.2		4.4		5.42	
Lead	400	3.04		0.906		0.526		1.06		0.849		2.04		2.73		2.41		0.766		1.1	
Mercury	2.3	0.0829	Ub	0.0775	Ub	0.0802	Ub	0.0821	Ub	0.0795	Ub	0.0825	Ub	0.0823	Ub	0.0802	Ub	0.0684	Ub	0.0853	Ub
Selenium	39	0.945		0.388	Ub	0.401	Ub	0.411	Ub	0.397	Ub	0.591		0.631		0.865		0.342	Ub	0.464	
Silver	39	0.414	Ub	0.388	Ub	0.401	Ub	0.411	Ub	0.397	Ub	0.412	Ub	0.411	Ub	0.401	Ub	0.342	Ub	0.426	Ub

a - All samples were collected by ECS Mid-Atlantic, LLC
b - Samples analyzed at dilution factor of 2
U - Undetected, value reported is the laboratory reporting limit
J - Indicates an estimated value between method detection limit and reporting limit
NA -not analyzed
ND- not detected
mg/kg - milligrams per kilogram
c - Anticipated Typical Concentrations for Eastern Maryland

Table 3

Groundwater Sampling Results for Additional Hydrogeochemical Parameters
Surficial Aquifer
Former Kop-Flex Facility
Hanover, Maryland (a, b)

Sample ID	**MW-05-31**		**MW-18-56**		**MW-38-28**		**TW-01-63**	
Date Sampled	10/02/14		10/02/14		10/02/14		10/02/14	
Parameters								
Metals (µg/L)								
Aluminum (total)	2,280		207		1,930		723	
Aluminum (dissolved)	2,190		165		1,400		692	
Copper (total)	10.7		5	U	5	U	9.4	
Copper (dissolved)	12.1		5.7		5	U	8.4	
Iron (total)	50	U	50	U	2,640		50	U
Iron (dissolved)	50	U	50	U	2,280		50	U
Lead (total)	5	U	5	U	5	U	5	U
Lead (dissolved)	5	U	5	U	5	U	5	U
Manganese (total)	71.6		17.6		7.7		15	
Manganese (dissolved)	70.3		17.1		7.3		14.7	
Nickel (total)	5	U	8.5		151		19.2	
Nickel (dissolved)	5	U	8.9		147		18.8	
Zinc (total)	16.3		10.3		175		11.4	
Zinc (dissolved)	25		18.2		171		10	U
Total Hardness (mg/L)	51.9		16.9		2.9		18.5	
Total Petroleum Hydrocarbons (mg/L)	5	U	5	U	5	U	5	U
Total Suspended Solids (mg/L)	5.1	U	3		27.3		2.5	U

---

a/ ug/L = micrograms per liter; mg/L = miligrams per liter

b/ Data Validation Qualifier:
U = analyte not detected above reporting limit

Table 4

Groundwater Sampling Results for Inorganic Parameters
Lower Patapsco Aquifer
Former Kop-Flex Facility
Hanover, Maryland (a, b)

Sample ID	**MW-1D**	**MW-2D**	**MW-16D**	**MW-17D**	**MW-21D**	**MW-26D**
Date Sampled	12/12/13	12/11/13	12/11/13	12/13/13	12/12/13	12/12/13
Parameters						
Metals (ug/L)						
Copper (total)	29	3.4	7.3	22	2.7	6.3
Copper (dissolved)	4.3	2	4.4	1 U	1.8	1.4
Iron (total)	430	100 U	290	3,400	150	200
Iron (dissolved)	130	100 U	100 U	100 U	100 U	100 U
Lead (total)	2	1 U	1 U	1.3	1 U	1 U
Lead (dissolved)	1 U	1 U	1 U	1 U	1 U	1 U
Manganese (total)	60	14	35	150	5.6	12
Manganese (dissolved)	46	12	25	11	3.7	8.7
Nickel (total)	22	9.5	20	20	3.1	6.1
Nickel (dissolved)	12	8.1	16	4.2	3.5	6.2
Zinc (total)	44	20 U	37	47	20 U	35
Zinc (dissolved)	22	20 U	32	20 U	20 U	20 U
Hardness (mg/L)	17	16	27	160	8.8	16
Total Alkalinity (mg/L)	17	NA	NA	140	10 U	13

---

a/ ug/L = micrograms per liter; mg/L = miligrams per liter; NA = not analyzed

b/ Data Validation Qualifier:

U = analyte not detected above reporting limit

Table 5

Aquifer Property Estimates from April-May 2014 Constant Rate Test on the Surficial Aquifer
Former Kop-Flex Facility
Hanover, Maryland

	Hydraulic Conductivity (feet/day) (a)		Transmissivity ($feet^2$/day)		
Well ID	**Drawdown**	**Recovery**	**Drawdown**	**Recovery**	**Storativity**
TW-1	5.2	5.8	146	162	---
MW-18	8.5	10.1	237	282	0.00071
MW-39	8.2	15.6	139	266	0.00082
OW-1	10.6	10.5	298	295	0.00073
OW-2	11	10.8	308	301	0.00087
Geometric Mean:	9.21		245		

---

a/ Hydraulic conductivity was calculate by dividing the transmissivity by the thickness of the sand unit. An average sand unit thickness of 28 feet was used for all wells except MW-39, where the thickness value was 17 feet.

Table 6

Aquifer Property Estimates from May 2014 Constant Rate Test
on the Lower Patapsco Aquifer
Former Kop-Flex Facility
Hanover, Maryland

	Hydraulic Conductivity (feet/day) (a)		Transmissivity (feet^2/day)		
Well ID	**Drawdown**	**Recovery**	**Drawdown**	**Recovery**	**Storativity**
TW-2	16.5	17.8	1,320	1,420	---
MW-1D	14.6	19.0	1,170	1,520	0.000092
MW-17D	17.8	17.5	1,420	1,400	0.00018
MW-21D	18.5	18.1	1,480	1,450	0.00015
MW-22D	17.3	16.3	1,380	1,300	0.00060
MW-24D	18.4	17.3	1,470	1,380	0.00060
MW-16D	19.3	---	1,540	---	0.00015
MW-26D	20.3	---	1,620	---	0.00011
Geometric Mean:	17.7		1,410		

---

a/ Hydraulic conductivity was calculate by dividing the transmissivity by the assumed thickness of the Lower Patapsco Aquifer (80 feet).

Table 7

Input Parameters for Steady State Flow Simulations in the Surficial Aquifer
Former Kop-Flex Facility
Hanover, Maryland

Parameter	Value	Source
Local Groundwater Flow Regime		
Upgradient Reference Head	115.5 feet MSL	Monitoring well hydrographs (2008-2014)
Hydraulic Gradient (magnitude)	0.008	2013 and 2014 groundwater surface contours
Hydraulic Gradient (direction)	West-Northwest	2013 and 2014 groundwater surface contours
Stony Run Head Values	106 - 108 feet MSL	Assumed values based on ground surface topography
Aquifer Properties		
Aquifer Top	124 feet MSL	Approximate ground surface elevation in main building are
Aquifer Bottom	67 feet MSL	Site hydrogeologic cross-sections
Porosity	0.35	Assumed value for unconsolidated silt and sand (Schwartz and Zheng 2003)
Hydraulic Conductivity	5.5 feet/day	Equivalent value for layered clayey and sandy deposits
Pond Recharge	0.001 feet/day	Assumed value from evaluation of flow system
Extraction Wells Design		
Screen Length	35 feet	
Depth to Top of Screen	22 feet	
Well Diameter	4 inches	
Borehole Diameter	8 inches	

Table 8

Proposed Recovery Well Construction and Operation Summary
Groundwater Containment System
Former Kop-Flex Facility
Hanover, Maryland (a, b)

Location	Aquifer	Well Diameter	Well Construction Material	Estimated Extraction Well Screened Interval			Anticipated Pump Intake Depth	Piezometer Diameter	Piezometer Construction Material	Estimated Piezometer Screened Interval			Anticipated Flow Rate	Maximum Flow Rate
		(inches)		(ft bgs)		(ft bgs)	(ft bgs)	(inches)	(inches)	(ft bgs)		(ft bgs)	(gpm)	(gpm)
RW-1S	Surficial	4	PVC	25	-	60	50	1	PVC	25	-	60	3.0	3.3
RW-2S	Surficial	4	PVC	25	-	60	50	1	PVC	25	-	60	3.0	3.3
RW-3S	Surficial	4	PVC	25	-	60	50	1	PVC	25	-	60	3.0	3.3
RW-1D	Lower Patapsco	6	PVC	100	-	140	90	1	PVC	100	-	140	35.0	38.5
RW-2D	Lower Patapsco	6	PVC	100	-	140	90	1	PVC	100	-	140	35.0	38.5
												Total:	79.0	86.9

---

a/ gpm = gallons per minute; ft bgs = feet below ground surface

b/ Maximum flow rate is the anticipated flow multiplied by a safety factor of 1.1.

Table 9

Input Parameters for Steady State Flow Simulations in the Lower Patapsco Aquifer
Former Kop-Flex Facility
Hanover, Maryland

Parameter	**Value**	**Source**
Local Groundwater Flow Regime		
Upgradient Reference Head	88 feet MSL	Well MW-23D hydrograph (2012-2014)
Hydraulic Gradient (magnitude)	0.006	2013 and 2014 potentiometric surface contours
Hydraulic Gradient (direction)	South-Southeast	2013 and 2014 potentiometric surface contours
Aquifer Properties		
Aquifer Top	50 feet MSL	Site hydrogeologic cross-sections
Aquifer Bottom	-30 feet MSL	Site hydrogeologic cross-sections
Porosity	0.30	Assumed value from published modeling studies of aquifer (Achmad 1991, Wilson and Achmad 1995)
Hydraulic Conductivity	15 feet/day	2014 constant discharge pumping test
Extraction Wells Design		
Screen Length	50 feet	
Depth to Top of Screen	100 feet	
Well Diameter	6 inches	
Borehole Diameter	10 inches	

Table 10

Previous NPDES Permit Monitoring Requirements
Former Kop-Flex Facility
Hanover, Maryland

		Quality or Concentration					
Parameter	**Units**	**Minimum**	**Monthly Average**	**Daily Maximum**	**Frequency of Analysis**	**Sample Type**	
Flow	gpd			-	1/Month	Measured	(a)
Total Volatile Organics	ug/l			100	1/Month	Grab	(a, b)
1,1-Dichloroethene	ug/l		32		1/Month	Grab	(a, b)
BOD5	mg/l		30	45	1/Month	Grab	
Total Suspended Solids	mg/l		30	45	1/Month	Grab	
Oil & Grease	mg/l			15	1/Month	Grab	
Dissolved Oxygen	mg/l	5			1/Month	Grab	
pH	SU	6.0		9.0	1/Month	Grab	
Total Zinc	ug/l			120	1/Month	Grab	(c)
Dissolved Zinc	ug/l			Report	1/Month	Grab	(c)
Total Copper	ug/l			13	1/Month	Grab	(c)
Dissolved Copper	ug/l			Report	1/Month	Grab	(c)
Total Nickel	ug/l			470	1/Month	Grab	(c)
Dissolved Nickel	ug/l			Report	1/Month	Grab	(c)
Total Lead	ug/l			65	1/Month	Grab	(c)
Dissolved Lead	ug/l			Report	1/Month	Grab	(c)
Hardness (as CaCO3)	mg/l			Report	1/Month	Grab	

There shall be no discharge of floating solids or persistent foam in other than trace amounts. Persistent foam is foam that does not dissipate within one half-hour of point of discharge.

---

a/ The Department may authorize a monitoring frequency reduction to once per month, based upon a written request by the permittee. Such a request shall describe the alternate method(s) being employed by the permittee to ensure consistent compliance with effluent limitations. These alternate methods may consist of alternate effluent monitoring tests and/or modified inspection, operation, or maintenance procedures which are used to prevent or predict effluent variability, or the additional use of carbon column units as part of the treatment system operation.

b/ Total Volatile Organics is defined as the sum of the constituents present in the wastewater according to EPA Method 601. The permittee shall include in the quarterly Discharge Monitoring Report the total sum and each individual concentration of detected constituents.

c/ The permittee shall use EPA Methods 200.7 or 200.8 for testing. An alternate test method may be substituted as long as the Department concurs that its detection level is less than the applicable Toxic Substance Criteria in COMAR 26.08.02.03 or the permittee demonstrates to the Department that a lower detection level is not practically achievable for this wastewater. Sample preservation procedures, container materials, and maximum allowable holding times must be specified in any application to the Department for use of an alternate test method(s). Written approval from the Department must be given before any alternate test method(s) is used. The integrity of all testing shall be ensured by following all sample preservation procedures, container materials, and maximum allowable holding times for the test method(s) specified. If a variance from the prescribed preservation techniques, container materials, and maximum holding times applicable is requested sufficient data shall be provided in the application to the Department to assure the integrity of the sample.

Table 11

Estimated Effluent Water Concentrations
Groundwater Containment System
Former Kop-Flex Facility
Hanover, Maryland

Constituents	Groundwater Cleanup Standards	Previous NPDES Permit Limits (b)	Estimated Effluent Water Concentration
VOC\:			
1,1,1-Trichloroethane	200	NS	< 200
1,1,2-Trichloroethane	5	NS	< 5
1,1-Dichloroethane	90	NS	< 90
1,1-Dichloroethene	7	32 (c)	< 7
1,2-Dichloroethane	5	NS	< 5
Trichloroethene	5	NS	< 5
cis-1,2-Dichloroethene	70	NS	< 70
Vinyl Chloride	2	NS	< 2
Total VOCs	-	100 (d)	< 100
1,4-dioxane	6	NS	< 6

---

a/ All concentrations provided in micrograms per liter (ug/l); NS = no standard; VOCs = volatile organic compounds

b/ NPDES Discharge Permit Limits provided by the site's State Discharge Permit No. 07-DP-3442 and NPDES Permit No. MD 0069094, which was issued on July 1, 2009, and expired on June 30, 2014. No discharge will be performed until the renewed permit is issued by MDE.

c/ NPDES permit monthly average concentration maximum.

d/ NPDES permit daily maximum concentration limit.

Appendix A – Engineering Design Drawings and Calculations

I N D E X OF D R A W I N G S

DRAWING NUMBER	SHEET NUMBER	DESCRIPTION
00003705-D41	1	TITLE SHEET
00003705-D46	2	GROUNDWATER COLLECTION AND TREATMENT SYSTEM PLAN
00003705-D43	3	PUMP INSTALLATION, PIPING, WELL VAULT, AND MISCELLANEOUS DETAILS
00003705-D44	4	CLEANOUT VAULT AND MISCELLANEOUS DETAILS
00003705-D45	5	GROUNDWATER TREATMENT PROCESSES

TITLE SHEET

GROUNDWATER COLLECTION AND TREATMENT SYSTEM

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND

PREPARED FOR

EMERSON
ST. LOUIS, MISSOURI

D

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REV	DESCRIPTION
1	Revised: Chkd: Appr:
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3	Revised: Chkd: Appr:

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APPROVED BJK 09/15/2015

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TITLE SHEET

GROUNDWATER COLLECTION AND TREATMENT SYSTEM
FORMER KOP–FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

WSP | PARSONS BRINCKERHOFF

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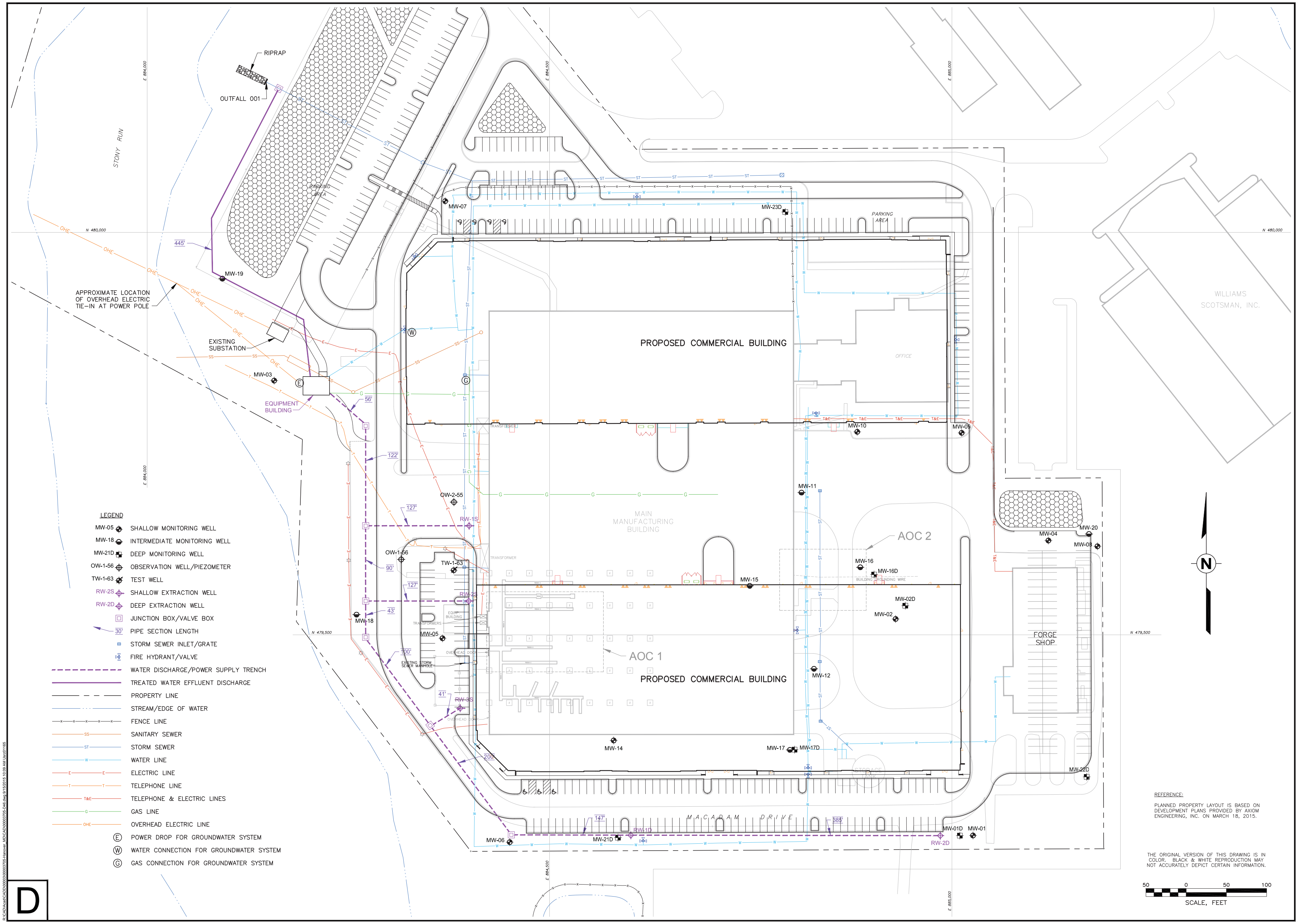
SHEET 1

Drawing Number
00003705–D41



REFERENCE:

PLANNED PROPERTY LAYOUT IS BASED ON DEVELOPMENT PLANS PROVIDED BY AXIOM ENGINEERING, INC. ON MARCH 18, 2015.

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CHECKED	BSK 09/14/2015
APPROVED	BSK 09/15/2015

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GROUNDWATER TREATMENT SYSTEM
UTILITY CONNECTION PLAN

FORMER KOP-FLEX FACILITY
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SHEET 2

Drawing Number
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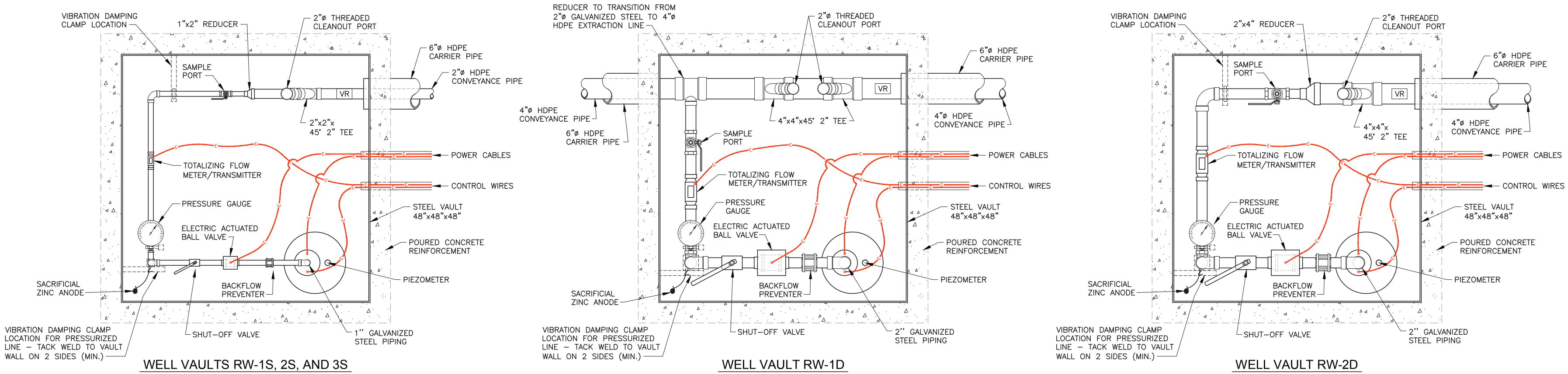


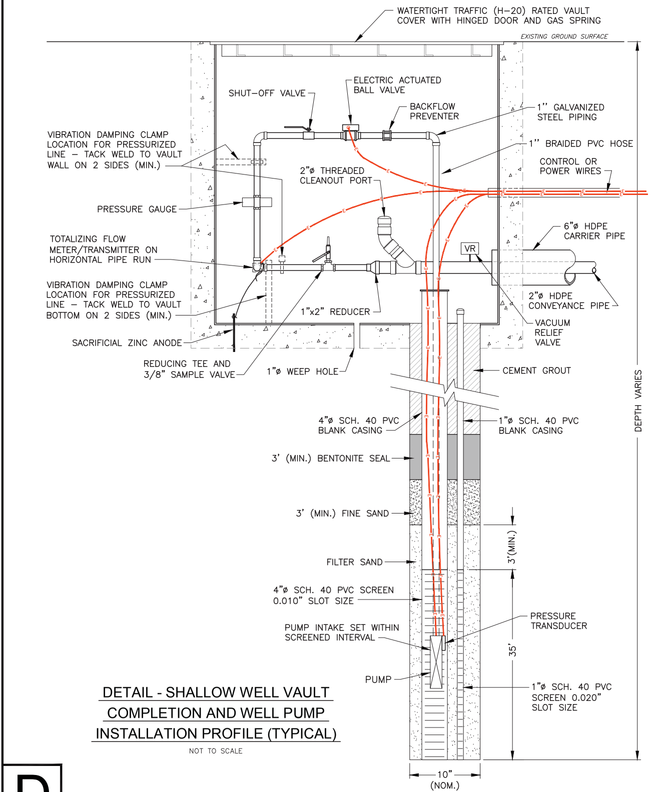
WELL VAULTS RW-1S, 2S, AND 3S

WELL VAULT RW-1D

WELL VAULT RW-2D

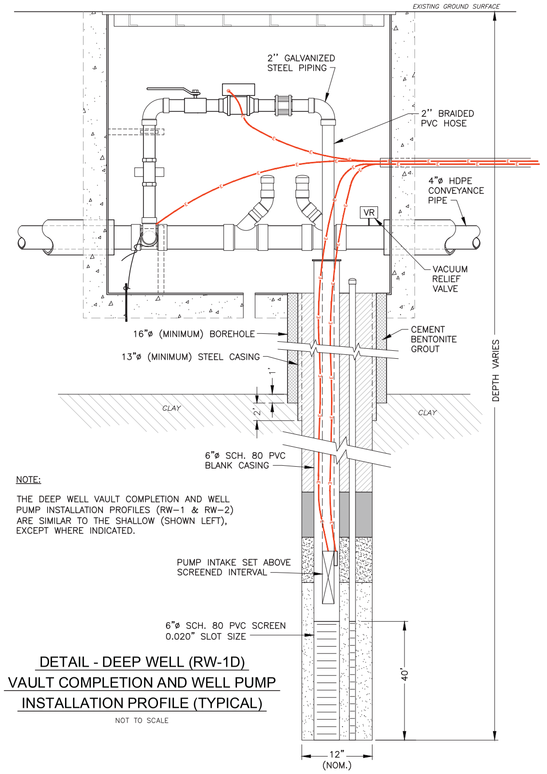
WELL VAULT COMPLETION AND WELL PUMP INSTALLATION PLAN DETAILS (TYPICAL)

NOT TO SCALE



DETAIL - SHALLOW WELL VAULT COMPLETION AND WELL PUMP INSTALLATION PROFILE (TYPICAL)

NOT TO SCALE

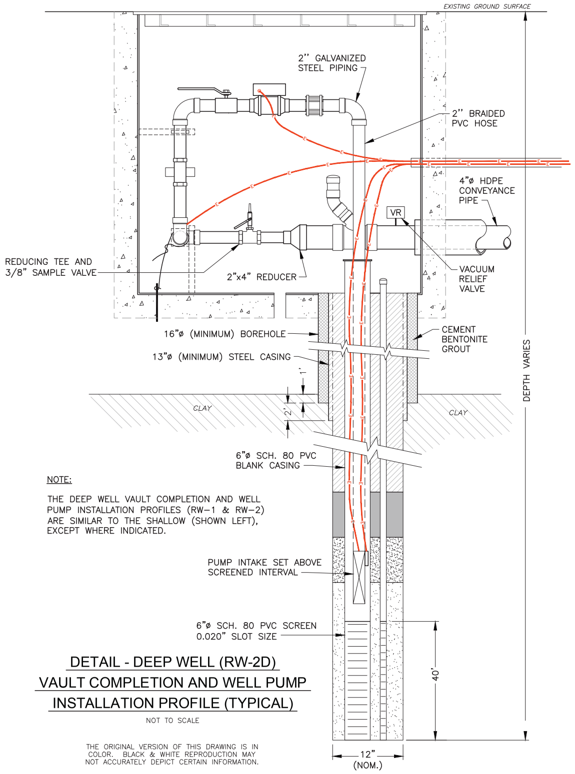


NOTE:

THE DEEP WELL VAULT COMPLETION AND WELL PUMP INSTALLATION PROFILES (RW–1 & RW–2) ARE SIMILAR TO THE SHALLOW (SHOWN LEFT), EXCEPT WHERE INDICATED.

DETAIL - DEEP WELL (RW-1D) VAULT COMPLETION AND WELL PUMP INSTALLATION PROFILE (TYPICAL)

NOT TO SCALE



NOTE:

THE DEEP WELL VAULT COMPLETION AND WELL PUMP INSTALLATION PROFILES (RW–1 & RW–2) ARE SIMILAR TO THE SHALLOW (SHOWN LEFT), EXCEPT WHERE INDICATED.

DETAIL - DEEP WELL (RW-2D) VAULT COMPLETION AND WELL PUMP INSTALLATION PROFILE (TYPICAL)

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3	Revised:	Chkd:	Appr.:

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STEPHEN JAMES KRETSCHMAN 43901

8/J Kretschman 9/14/15

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PUMP INSTALLATION, PIPING, WELL VAULT, AND MISCELLANEOUS DETAILS

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SHEET 3

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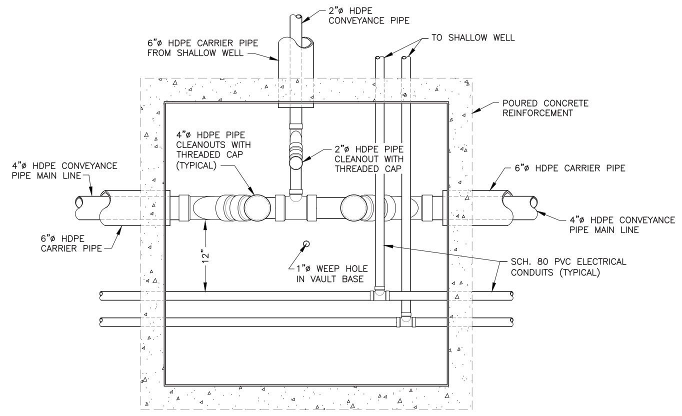
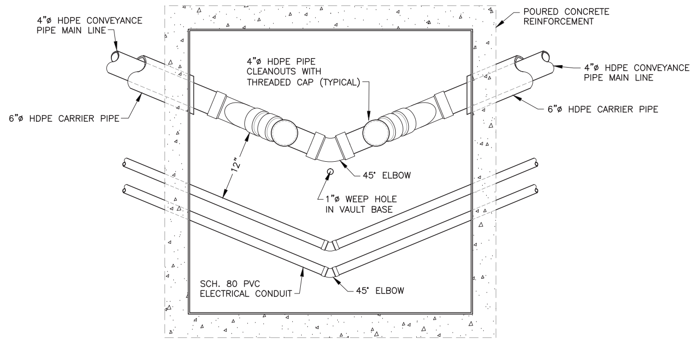


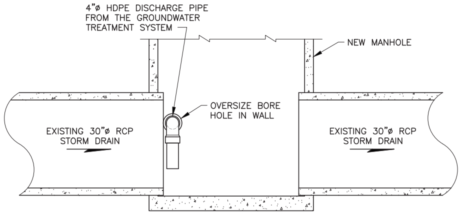
TEE CLEANOUT VAULT / JUNCTION BOX PLAN VIEW

APPROXIMATE SCALE, INCHES
0 10 20



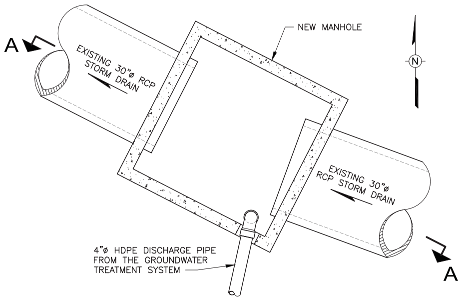
45° CLEANOUT VAULT PLAN VIEW

APPROXIMATE SCALE, INCHES
0 10 20



DETAIL - DISCHARGE MANHOLE SECTION A-A

NOT TO SCALE



DISCHARGE MANHOLE PLAN VIEW

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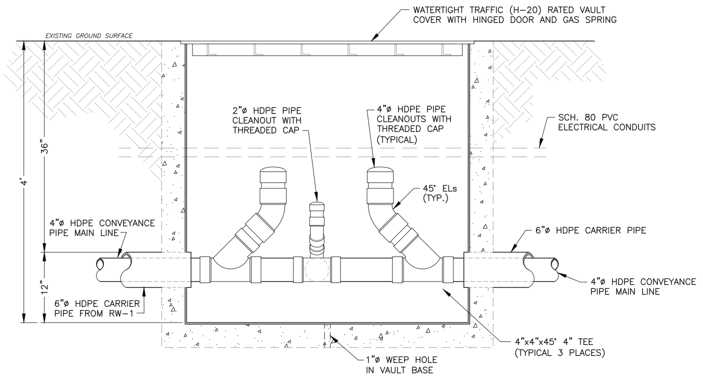

TEE CLEANOUT VAULT / JUNCTION BOX PROFILE

APPROXIMATE SCALE, INCHES
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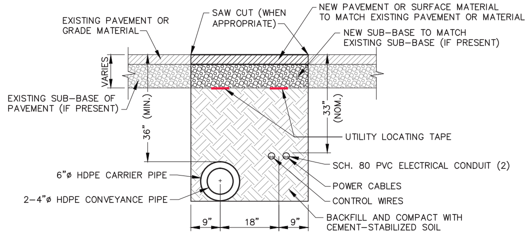

TYPICAL TRENCH SECTION

NOT TO SCALE

(WATER CONVEYANCE & CARRIER PIPES, CONTROL WIRES & POWER CABLES, AND CONDUITS)

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CLEANOUT VAULT AND MISCELLANEOUS DETAILS

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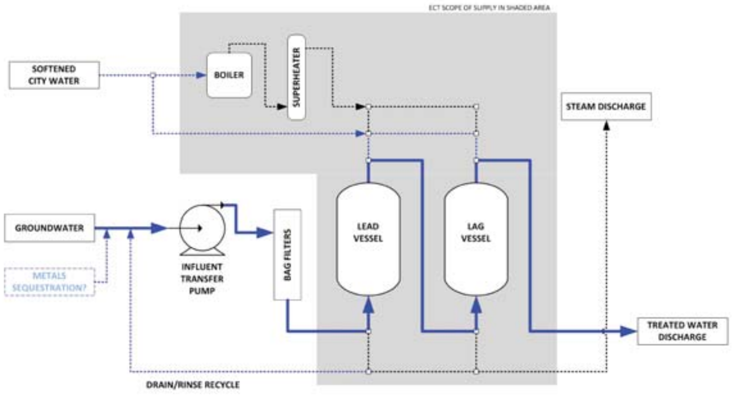
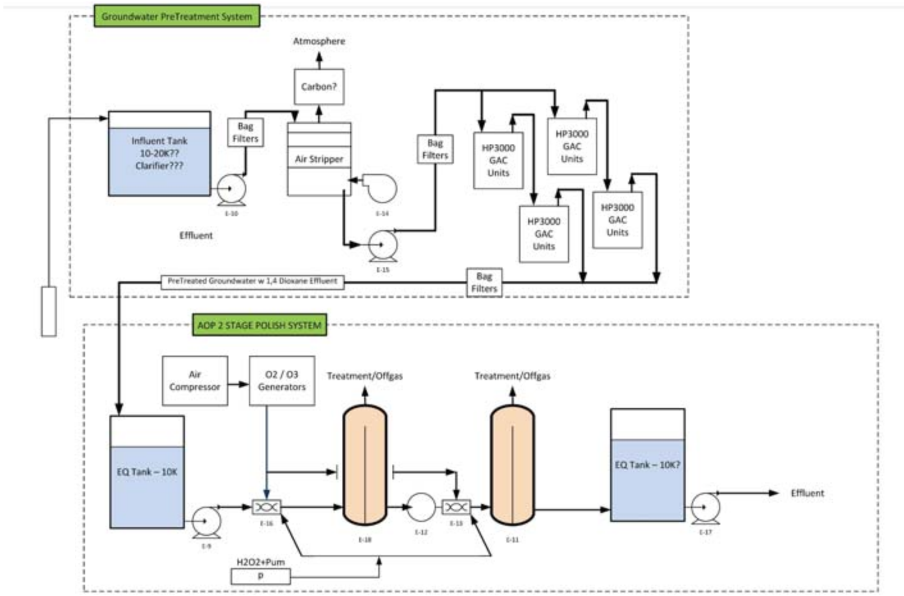


PRELIMINARY GROUNDWATER TREATMENT DESIGN

SYNTHETIC RESIN PROCESS



ALTERNATE GROUNDWATER TREATMENT DESIGN

ADVANCED OXIDATION PROCESS

NOTE:

THE GROUNDWATER TREATMENT PROCESS WILL BE SELECTED FOLLOWING PRE-DESIGN TESTING. SEE THE RESPONSE ACTION PLAN FOR MORE INFORMATION.

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△	Revised:	Chkd:	Appr.:

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GROUNDWATER TREATMENT PROCESSES

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SHEET 5

Drawing Number
00003705–D45

Appendix B – Analytical Results

Analytical Report for

WSP Environment & Energy - Reston

Certificate of Analysis No.: 13121306

Project Manager: James Edwards
Project Name : Kop-Flex
Project Location: Hanover, MD
Project ID : 3705-07

December 20, 2013

Phase Separation Science, Inc.
6630 Baltimore National Pike
Baltimore, MD 21228
Phone: (410) 747-8770
Fax: (410) 788-8723

OFFICES:
6630 BALTIMORE NATIONAL PIKE
ROUTE 40 WEST
BALTIMORE, MD 21228
410-747-8770
800-932-9047
FAX 410-788-8723

PHASE SEPARATION SCIENCE, INC.

December 20, 2013

James Edwards
WSP Environment & Energy - Reston
11190 Sunrise Valley Dr., Ste. 300
Reston, VA 20191

Reference: PSS Work Order(s) No: **13121306**
Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID.: 3705-07

Dear James Edwards :

This report includes the analytical results from the analyses performed on the samples received under the project name referenced above and identified with the Phase Separation Science (PSS) Work Order(s) numbered **13121306**.

All work reported herein has been performed in accordance with current NELAP standards, referenced methodologies, PSS Standard Operating Procedures and the PSS Quality Assurance Manual unless otherwise noted in the Case Narrative Summary. PSS is limited in liability to the actual cost of the sample analysis done.

PSS reserves the right to return any unused samples, extracts or related solutions. Otherwise, the samples are scheduled for disposal, without any further notice, on January 17, 2014. This includes any samples that were received with a request to be held but lacked a specific hold period. It is your responsibility to provide a written request defining a specific disposal date if additional storage is required. Upon receipt , the request will be acknowledged by PSS, thus extending the storage period.

This report shall not be reproduced except in full, without the written approval of an authorized PSS representative. A copy of this report will be retained by PSS for at least 5 years, after which time it will be disposed of without further notice, unless prior arrangements have been made.

We thank you for selecting Phase Separation Science, Inc. to serve your analytical needs. If you have any questions concerning this report, do not hesitate to contact us at 410-747-8770 or info@phaseonline.com.

Sincerely,

Dan Prucnal

Dan Prucnal
Laboratory Manager

Sample Summary

Client Name: WSP Environment & Energy - Reston

Project Name: Kop-Flex

Work Order Number(s): 13121306

Project ID: 3705-07

The following samples were received under chain of custody by Phase Separation Science (PSS) on 12/13/2013 at 11:39 am

Lab Sample Id	Sample Id	Matrix	Date/Time Collected
13121306-001	MW-26D	WATER	12/12/13 09:00
13121306-002	MW-26D	WATER	12/12/13 09:00
13121306-003	MW-21D	WATER	12/12/13 10:55
13121306-004	MW-21D	WATER	12/12/13 10:55
13121306-005	MW-1D	WATER	12/12/13 15:55
13121306-006	MW-1D	WATER	12/12/13 15:55
13121306-007	MW-17D	WATER	12/13/13 09:20
13121306-008	MW-17D	WATER	12/13/13 09:20
13121306-009	MW-22D	WATER	12/12/13 12:55
13121306-010	MW-22D	WATER	12/12/13 12:55
13121306-011	MW-2D	WATER	12/11/13 16:40
13121306-012	MW-2D	WATER	12/11/13 16:40
13121306-013	MW-16D	WATER	12/11/13 11:02
13121306-014	MW-16D	WATER	12/11/13 11:02

Please reference the Chain of Custody and Sample Receipt Checklist for specific container counts and preservatives. Any sample conditions not in compliance with sample acceptance criteria are described in Case Narrative Summary.

Notes:

1. The presence of a common laboratory contaminant such as methylene chloride may be considered a possible laboratory artifact. Where observed, appropriate consideration of data should be taken.
2. The following analytical results are never reported on a dry weight basis: pH, flashpoint, moisture and paint filter test.
3. Drinking water samples collected for the purpose of compliance with SDWA may not be suitable for their intended use unless collected by a certified sampler [COMAR 26.08.05.07.C.2].
4. The analyses of 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB) by EPA 524.2 and calcium, magnesium, sodium and iron by EPA 200.8 are not currently promulgated for use in testing to meet the Safe Drinking Water Act and as such cannot be used for compliance purposes. The listings of the current promulgated methods for testing in compliance with the Safe Drinking Water Act can be found in the 40 CFR part 141.1, for the primary drinking water contaminates, and part 141.3, for the secondary drinking water contaminates.
5. The analyses of chlorine, pH, dissolved oxygen, temperature and sulfite for non-potable water samples tested for compliance for Virginia Pollution Discharge Elimination System (VDPES) permits and Virginia Pollutant Abatement (VPA) permits, have a maximum holding time of 15 minutes established by 40CFR136.3.
6. Sample prepared under EPA 3550C with concentrations greater than 20 mg/Kg should employ the microtip extraction procedure if required to meet data quality objectives.

Standard Flags/Abbreviations:

B	A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
C	Results Pending Final Confirmation.
E	The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
Fail	The result exceeds the regulatory level for Toxicity Characteristic (TCLP) as cited in 40 CFR 261.24 Table 1.
J	The target analyte was positively identified below the reporting limit but greater than the LOD.
LOD	Limit of Detection. An estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte and matrix specific.
ND	Not Detected at or above the reporting limit.
RL	PSS Reporting Limit.
U	Not detected.

Sample Summary

Client Name: WSP Environment & Energy - Reston

Project Name: Kop-Flex

Work Order Number(s): **13121306**

Certifications:

NELAP Certifications: PA 68-03330, VA 2200
State Certifications: MD 179, WV 303
Regulated Soil Permit: P330-12-00268
NSWC USCG Accepted Laboratory
LDBA MWAA LD1997-0041-2015

CERTIFICATE OF ANALYSIS

No: 13121306
WSP Environment & Energy - Reston, Reston, VA
December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-26D **Date/Time Sampled: 12/12/2013 09:00** **PSS Sample ID: 13121306-001**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**6.3**	ug/L	1.0		1	12/16/13	12/20/13 13:57	1034
Iron	**200**	ug/L	100		1	12/16/13	12/17/13 19:56	1034
Lead	ND	ug/L	1.0		1	12/16/13	12/17/13 19:56	1034
Manganese	**12**	ug/L	1.0		1	12/16/13	12/17/13 19:56	1034
Nickel	**6.1**	ug/L	1.0		1	12/16/13	12/17/13 19:56	1034
Zinc	**35**	ug/L	20		1	12/16/13	12/17/13 19:56	1034
Hardness (Ca & Mg)	**16**	mg/L	0.66		1	12/16/13	12/17/13 19:56	1034

Alkalinity Analytical Method: EPA 310.2 Preparation Method: ALKALINITY

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Alkalinity, Total (CaCO3)	**13**	mg/L	10		1	12/20/13	12/20/13 12:24	1044

Sample ID: MW-26D **Date/Time Sampled: 12/12/2013 09:00** **PSS Sample ID: 13121306-002**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**1.4**	ug/L	1.0		1	12/18/13	12/18/13 18:01	1034
Iron	ND	ug/L	100		1	12/18/13	12/18/13 18:01	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 18:01	1034
Manganese	**8.7**	ug/L	1.0		1	12/18/13	12/18/13 18:01	1034
Nickel	**6.2**	ug/L	1.0		1	12/18/13	12/18/13 18:01	1034
Zinc	ND	ug/L	20		1	12/18/13	12/18/13 18:01	1034

CERTIFICATE OF ANALYSIS

No: 13121306
WSP Environment & Energy - Reston, Reston, VA
December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-21D **Date/Time Sampled: 12/12/2013 10:55** **PSS Sample ID: 13121306-003**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**2.7**	ug/L	1.0		1	12/16/13	12/20/13 14:03	1034
Iron	**150**	ug/L	100		1	12/16/13	12/17/13 20:26	1034
Lead	ND	ug/L	1.0		1	12/16/13	12/17/13 20:26	1034
Manganese	**5.6**	ug/L	1.0		1	12/16/13	12/17/13 20:26	1034
Nickel	**3.1**	ug/L	1.0		1	12/16/13	12/17/13 20:26	1034
Zinc	ND	ug/L	20		1	12/16/13	12/17/13 20:26	1034
Hardness (Ca & Mg)	**8.8**	mg/L	0.66		1	12/16/13	12/17/13 20:26	1034

Alkalinity Analytical Method: EPA 310.2 Preparation Method: ALKALINITY

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Alkalinity, Total (CaCO3)	ND	mg/L	10		1	12/20/13	12/20/13 12:26	1044

Sample ID: MW-21D **Date/Time Sampled: 12/12/2013 10:55** **PSS Sample ID: 13121306-004**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**1.8**	ug/L	1.0		1	12/18/13	12/18/13 18:43	1034
Iron	ND	ug/L	100		1	12/18/13	12/18/13 18:43	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 18:43	1034
Manganese	**3.7**	ug/L	1.0		1	12/18/13	12/18/13 18:43	1034
Nickel	**3.5**	ug/L	1.0		1	12/18/13	12/18/13 18:43	1034
Zinc	ND	ug/L	20		1	12/18/13	12/18/13 18:43	1034

CERTIFICATE OF ANALYSIS

No: 13121306

WSP Environment & Energy - Reston, Reston, VA

December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-1D **Date/Time Sampled: 12/12/2013 15:55** **PSS Sample ID: 13121306-005**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**29**	ug/L	1.0		1	12/16/13	12/17/13 20:32	1034
Iron	**430**	ug/L	100		1	12/16/13	12/17/13 20:32	1034
Lead	**2.0**	ug/L	1.0		1	12/16/13	12/17/13 20:32	1034
Manganese	**60**	ug/L	1.0		1	12/16/13	12/17/13 20:32	1034
Nickel	**22**	ug/L	1.0		1	12/16/13	12/17/13 20:32	1034
Zinc	**44**	ug/L	20		1	12/16/13	12/17/13 20:32	1034
Hardness (Ca & Mg)	**17**	mg/L	2.9		1	12/16/13	12/17/13 20:32	1034

Alkalinity Analytical Method: EPA 310.2 Preparation Method: ALKALINITY

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Alkalinity, Total (CaCO3)	**17**	mg/L	10		1	12/20/13	12/20/13 12:27	1044

Sample ID: MW-1D **Date/Time Sampled: 12/12/2013 15:55** **PSS Sample ID: 13121306-006**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**4.3**	ug/L	1.0		1	12/18/13	12/18/13 18:49	1034
Iron	**130**	ug/L	100		1	12/18/13	12/18/13 18:49	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 18:49	1034
Manganese	**46**	ug/L	1.0		1	12/18/13	12/18/13 18:49	1034
Nickel	**12**	ug/L	1.0		1	12/18/13	12/18/13 18:49	1034
Zinc	**22**	ug/L	20		1	12/18/13	12/18/13 18:49	1034

CERTIFICATE OF ANALYSIS

No: 13121306
WSP Environment & Energy - Reston, Reston, VA
December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-17D **Date/Time Sampled: 12/13/2013 09:20** **PSS Sample ID: 13121306-007**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**22**	ug/L	1.0		1	12/16/13	12/17/13 20:38	1034
Iron	**3,400**	ug/L	100		1	12/16/13	12/17/13 20:38	1034
Lead	**1.3**	ug/L	1.0		1	12/16/13	12/17/13 20:38	1034
Manganese	**150**	ug/L	1.0		1	12/16/13	12/17/13 20:38	1034
Nickel	**20**	ug/L	1.0		1	12/16/13	12/17/13 20:38	1034
Zinc	**47**	ug/L	20		1	12/16/13	12/17/13 20:38	1034
Hardness (Ca & Mg)	**160**	mg/L	25		1	12/16/13	12/17/13 20:38	1034

Alkalinity Analytical Method: EPA 310.2 Preparation Method: ALKALINITY

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Alkalinity, Total (CaCO3)	**140**	mg/L	20		2	12/20/13	12/20/13 12:47	1044

Sample ID: MW-17D **Date/Time Sampled: 12/13/2013 09:20** **PSS Sample ID: 13121306-008**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	ND	ug/L	1.0		1	12/18/13	12/18/13 18:55	1034
Iron	ND	ug/L	100		1	12/18/13	12/18/13 18:55	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 18:55	1034
Manganese	**11**	ug/L	1.0		1	12/18/13	12/18/13 18:55	1034
Nickel	**4.2**	ug/L	1.0		1	12/18/13	12/18/13 18:55	1034
Zinc	ND	ug/L	20		1	12/18/13	12/18/13 18:55	1034

CERTIFICATE OF ANALYSIS

No: 13121306
WSP Environment & Energy - Reston, Reston, VA
December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-22D **Date/Time Sampled: 12/12/2013 12:55** **PSS Sample ID: 13121306-009**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**4.7**	ug/L	1.0		1	12/16/13	12/20/13 14:10	1034
Iron	ND	ug/L	100		1	12/16/13	12/17/13 20:44	1034
Lead	ND	ug/L	1.0		1	12/16/13	12/17/13 20:44	1034
Manganese	**11**	ug/L	1.0		1	12/16/13	12/17/13 20:44	1034
Nickel	**9.0**	ug/L	1.0		1	12/16/13	12/17/13 20:44	1034
Zinc	ND	ug/L	20		1	12/16/13	12/17/13 20:44	1034
Hardness (Ca & Mg)	**14**	mg/L	0.66		1	12/16/13	12/17/13 20:44	1034

Alkalinity Analytical Method: EPA 310.2 Preparation Method: ALKALINITY

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Alkalinity, Total (CaCO3)	ND	mg/L	10		1	12/20/13	12/20/13 12:29	1044

Sample ID: MW-22D **Date/Time Sampled: 12/12/2013 12:55** **PSS Sample ID: 13121306-010**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**3.0**	ug/L	1.0		1	12/18/13	12/18/13 19:01	1034
Iron	ND	ug/L	100		1	12/18/13	12/18/13 19:01	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 19:01	1034
Manganese	**9.0**	ug/L	1.0		1	12/18/13	12/18/13 19:01	1034
Nickel	**7.6**	ug/L	1.0		1	12/18/13	12/18/13 19:01	1034
Zinc	ND	ug/L	20		1	12/18/13	12/18/13 19:01	1034

CERTIFICATE OF ANALYSIS

No: 13121306
WSP Environment & Energy - Reston, Reston, VA
December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-2D **Date/Time Sampled: 12/11/2013 16:40** **PSS Sample ID: 13121306-011**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**3.4**	ug/L	1.0		1	12/16/13	12/20/13 14:40	1034
Iron	ND	ug/L	100		1	12/16/13	12/17/13 20:50	1034
Lead	ND	ug/L	1.0		1	12/16/13	12/17/13 20:50	1034
Manganese	**14**	ug/L	1.0		1	12/16/13	12/17/13 20:50	1034
Nickel	**9.5**	ug/L	1.0		1	12/16/13	12/17/13 20:50	1034
Zinc	ND	ug/L	20		1	12/16/13	12/17/13 20:50	1034
Hardness (Ca & Mg)	**16**	mg/L	0.66		1	12/16/13	12/17/13 20:50	1034

Sample ID: MW-2D **Date/Time Sampled: 12/11/2013 16:40** **PSS Sample ID: 13121306-012**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**2.0**	ug/L	1.0		1	12/18/13	12/18/13 19:07	1034
Iron	ND	ug/L	100		1	12/18/13	12/18/13 19:07	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 19:07	1034
Manganese	**12**	ug/L	1.0		1	12/18/13	12/18/13 19:07	1034
Nickel	**8.1**	ug/L	1.0		1	12/18/13	12/18/13 19:07	1034
Zinc	ND	ug/L	20		1	12/18/13	12/18/13 19:07	1034

Sample ID: MW-16D **Date/Time Sampled: 12/11/2013 11:02** **PSS Sample ID: 13121306-013**
Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytical Method: EPA 200.8 Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**7.3**	ug/L	1.0		1	12/16/13	12/20/13 14:46	1034
Iron	**290**	ug/L	100		1	12/16/13	12/17/13 20:56	1034
Lead	ND	ug/L	1.0		1	12/16/13	12/17/13 20:56	1034
Manganese	**35**	ug/L	1.0		1	12/16/13	12/17/13 20:56	1034
Nickel	**20**	ug/L	1.0		1	12/16/13	12/17/13 20:56	1034
Zinc	**37**	ug/L	20		1	12/16/13	12/17/13 20:56	1034
Hardness (Ca & Mg)	**27**	mg/L	2.9		1	12/16/13	12/17/13 20:56	1034

CERTIFICATE OF ANALYSIS

No: 13121306

WSP Environment & Energy - Reston, Reston, VA

December 20, 2013

Project Name: Kop-Flex
Project Location: Hanover, MD
Project ID: 3705-07

Sample ID: MW-16D **Date/Time Sampled: 12/11/2013 11:02** **PSS Sample ID: 13121306-014**

Matrix: WATER **Date/Time Received: 12/13/2013 11:39**

Dissolved Cu, Pb, Zn, Fe, Mn, Ni   Analytical Method: EPA 200.8   Preparation Method: 200.8

	Result	Units	RL	Flag	Dil	Prepared	Analyzed	Analyst
Copper	**4.4**	ug/L	1.0		1	12/18/13	12/18/13 19:13	1034
Iron	ND	ug/L	100		1	12/18/13	12/18/13 19:13	1034
Lead	ND	ug/L	1.0		1	12/18/13	12/18/13 19:13	1034
Manganese	**25**	ug/L	1.0		1	12/18/13	12/18/13 19:13	1034
Nickel	**16**	ug/L	1.0		1	12/18/13	12/18/13 19:13	1034
Zinc	**32**	ug/L	20		1	12/18/13	12/18/13 19:13	1034

Case Narrative Summary

Client Name: WSP Environment & Energy - Reston

Project Name: Kop-Flex

Work Order Number(s): 13121306
Project ID: 3705-07

Any holding time exceedances, deviations from the method specifications, regulatory requirements or variations to the procedures outlined in the PSS Quality Assurance Manual are outlined below.

Sample Receipt:

Two coolers were received. All sample receipt conditions were acceptable. The temperatures observed were 5 and 6 degrees C.

General Comments:

Nickel added to metals analysis per client. Hold Alkalinity for sample MW-16D and MW-2D per client.

NELAP accreditation was held for all analyses performed unless noted below. See www.phaseonline.com for complete PSS scope of accreditation.

Analytical Data Package Information Summary

Work Order(s): 13121306
Report Prepared For: WSP Environment & Energy - Reston, Reston
Project Name: Kop-Flex
Project Manager: James Edwards

Method	Client Sample Id	Analysis Type	Lab Sample Id	Analyst	Mtx	Prep Batch	Analytical Batch	Sampled	Prepared	Analyzed
EPA 200.8	MW-26D	Initial	13121306-001	1034	W	48489	110691	12/12/2013	12/16/2013 08:53	12/17/2013 19:56
	MW-21D	Initial	13121306-003	1034	W	48489	110691	12/12/2013	12/16/2013 08:53	12/17/2013 20:26
	MW-1D	Initial	13121306-005	1034	W	48489	110691	12/12/2013	12/16/2013 08:53	12/17/2013 20:32
	MW-17D	Initial	13121306-007	1034	W	48489	110691	12/13/2013	12/16/2013 08:53	12/17/2013 20:38
	MW-22D	Initial	13121306-009	1034	W	48489	110691	12/12/2013	12/16/2013 08:53	12/17/2013 20:44
	MW-2D	Initial	13121306-011	1034	W	48489	110691	12/11/2013	12/16/2013 08:53	12/17/2013 20:50
	MW-16D	Initial	13121306-013	1034	W	48489	110691	12/11/2013	12/16/2013 08:53	12/17/2013 20:56
	48489-1-BKS	BKS	48489-1-BKS	1034	W	48489	110691	--------	12/16/2013 08:53	12/17/2013 18:20
	48489-1-BLK	BLK	48489-1-BLK	1034	W	48489	110691	--------	12/16/2013 08:53	12/17/2013 18:14
	Metals - 3 S	MS	13121207-003 S	1034	W	48489	110691	12/11/2013	12/16/2013 08:53	12/17/2013 18:32
	Outfall-2 S	MS	13121307-002 S	1034	W	48489	110691	12/12/2013	12/16/2013 08:53	12/17/2013 21:14
	Metals - 3 SD	MSD	13121207-003 SD	1034	W	48489	110691	12/11/2013	12/16/2013 08:53	12/17/2013 18:38
	MW-26D	Reanalysis	13121306-001	1034	W	48489	110794	12/12/2013	12/16/2013 08:53	12/20/2013 13:57
	MW-21D	Reanalysis	13121306-003	1034	W	48489	110794	12/12/2013	12/16/2013 08:53	12/20/2013 14:03
	MW-22D	Reanalysis	13121306-009	1034	W	48489	110794	12/12/2013	12/16/2013 08:53	12/20/2013 14:10
	MW-2D	Reanalysis	13121306-011	1034	W	48489	110794	12/11/2013	12/16/2013 08:53	12/20/2013 14:40
	MW-16D	Reanalysis	13121306-013	1034	W	48489	110794	12/11/2013	12/16/2013 08:53	12/20/2013 14:46
	48577-1-BKS	BKS	48577-1-BKS	1034	W	48577	110794	--------	12/20/2013 08:37	12/20/2013 13:34
	48577-1-BLK	BLK	48577-1-BLK	1034	W	48577	110794	--------	12/20/2013 08:37	12/20/2013 13:27
	Outfall-2 DL RE SD	MSD	13121307-002 SD	1034	W	48577	110794	12/12/2013	12/20/2013 08:37	12/20/2013 13:51
EPA 200.8	MW-26D	Initial	13121306-002	1034	W	48534	110738	12/12/2013	12/18/2013 09:19	12/18/2013 18:01
	MW-21D	Initial	13121306-004	1034	W	48534	110738	12/12/2013	12/18/2013 09:19	12/18/2013 18:43
	MW-1D	Initial	13121306-006	1034	W	48534	110738	12/12/2013	12/18/2013 09:19	12/18/2013 18:49
	MW-17D	Initial	13121306-008	1034	W	48534	110738	12/13/2013	12/18/2013 09:19	12/18/2013 18:55
	MW-22D	Initial	13121306-010	1034	W	48534	110738	12/12/2013	12/18/2013 09:19	12/18/2013 19:01
	MW-2D	Initial	13121306-012	1034	W	48534	110738	12/11/2013	12/18/2013 09:19	12/18/2013 19:07
	MW-16D	Initial	13121306-014	1034	W	48534	110738	12/11/2013	12/18/2013 09:19	12/18/2013 19:13
	48534-1-BKS	BKS	48534-1-BKS	1034	W	48534	110738	--------	12/18/2013 09:19	12/18/2013 17:55
	48534-1-BLK	BLK	48534-1-BLK	1034	W	48534	110738	--------	12/18/2013 09:19	12/18/2013 17:49

Analytical Data Package Information Summary

Work Order(s): 13121306
Report Prepared For: WSP Environment & Energy - Reston, Reston
Project Name: Kop-Flex
Project Manager: James Edwards

Method	Client Sample Id	Analysis Type	Lab Sample Id	Analyst	Mtx	Prep Batch	Analytical Batch	Sampled	Prepared	Analyzed
EPA 200.8	MW-26D S	MS	13121306-002 S	1034	W	48534	110738	12/12/2013	12/18/2013 09:19	12/18/2013 18:31
	MW-26 SD	MSD	13121306-002 SD	1034	W	48534	110738	12/12/2013	12/18/2013 09:19	12/18/2013 18:37
EPA 310.2	MW-26D	Initial	13121306-001	1044	W	48586	110791	12/12/2013	12/20/2013 14:09	12/20/2013 12:24
	MW-21D	Initial	13121306-003	1044	W	48586	110791	12/12/2013	12/20/2013 14:09	12/20/2013 12:26
	MW-1D	Initial	13121306-005	1044	W	48586	110791	12/12/2013	12/20/2013 14:09	12/20/2013 12:27
	MW-17D	Initial	13121306-007	1044	W	48586	110791	12/13/2013	12/20/2013 14:09	12/20/2013 12:47
	MW-22D	Initial	13121306-009	1044	W	48586	110791	12/12/2013	12/20/2013 14:09	12/20/2013 12:29
	48586-1-BKS	BKS	48586-1-BKS	1044	W	48586	110791	--------	12/20/2013 14:09	12/20/2013 12:21
	48586-1-BLK	BLK	48586-1-BLK	1044	W	48586	110791	--------	12/20/2013 14:09	12/20/2013 12:20
	48586-1-BSD	BSD	48586-1-BSD	1044	W	48586	110791	--------	12/20/2013 14:09	12/20/2013 12:23
	MW-26 D	MD	13121306-001 D	1044	W	48586	110791	12/12/2013	12/20/2013 14:09	12/20/2013 12:25

Blank Summary 13121306

WSP Environment & Energy - Reston, Reston, VA

Kop-Flex

Analytical Method: **EPA 200.8** Prep Method: E200.8_PREP
Matrix: **WATER**

Sample Id: **48534-1-BLK** Lab Sample Id: **48534-1-BLK**
Date Analyzed: Dec-18-13 17:49 Analyst: 1034 Date Prep: Dec-18-13 09:19 Tech: 1033
Seq Number: 110738

Parameter	Cas Number	Result	RL	LOD	Units	Flag	Dil
Copper	7440-50-8	ND	1.000	0.5000	ug/L	U	1
Iron	7439-89-6	ND	100	50.00	ug/L	U	1
Lead	7439-92-1	ND	1.000	0.5000	ug/L	U	1
Manganese	7439-96-5	ND	1.000	0.5000	ug/L	U	1
Nickel	7440-02-0	ND	1.000	0.5000	ug/L	U	1
Zinc	7440-66-6	ND	20.00	10.00	ug/L	U	1
Hardness (Ca & Mg)	HARDCAM(	ND	0.7000	0.7000	mg/L	U	1

Blank Summary 13121306

WSP Environment & Energy - Reston, Reston, VA

Kop-Flex

Analytical Method: **EPA 200.8** Prep Method: E200.8_PREP
Matrix: **WATER**

Sample Id: **48489-1-BLK** Lab Sample Id: **48489-1-BLK**
Date Analyzed: Dec-17-13 18:14 Analyst: 1034 Date Prep: Dec-16-13 08:53 Tech: 1034
Seq Number: 110691

Parameter	Cas Number	Result	RL	LOD	Units	Flag	Dil
Calcium	7440-70-2	ND	100	50.00	ug/L	U	1
Copper	7440-50-8	1.320	1.000	0.5000	ug/L		1
Iron	7439-89-6	ND	100	50.00	ug/L	U	1
Lead	7439-92-1	ND	1.000	0.5000	ug/L	U	1
Magnesium	7439-95-4	ND	100	50.00	ug/L	U	1
Manganese	7439-96-5	ND	1.000	0.5000	ug/L	U	1
Nickel	7440-02-0	ND	1.000	0.5000	ug/L	U	1
Zinc	7440-66-6	ND	20.00	10.00	ug/L	U	1
Hardness (Ca & Mg)	HARDCAM(	ND	0.7000	0.7000	mg/L	U	1

Sample Id: **48577-1-BLK** Lab Sample Id: **48577-1-BLK**
Date Analyzed: Dec-20-13 13:27 Analyst: 1034 Date Prep: Dec-20-13 08:37 Tech: 1034
Seq Number: 110794

Parameter	Cas Number	Result	RL	LOD	Units	Flag	Dil
Copper	7440-50-8	ND	1.000	0.5000	ug/L	U	1

Blank Summary 13121306

WSP Environment & Energy - Reston, Reston, VA

Kop-Flex

Analytical Method: **EPA 310.2** Prep Method: Alkalinity_Prep
Matrix: **WATER**

Sample Id: **48586-1-BLK** Lab Sample Id: **48586-1-BLK**
Date Analyzed: Dec-20-13 12:20 Analyst: 1044 Date Prep: Dec-20-13 14:09 Tech: 1044
Seq Number: 110791

Parameter	Cas Number	Result	RL	LOD	Units	Flag	Dil
Alkalinity, Total (CaCO3)		ND	10.00	10.00	mg/L	U	1

Blank Spike Recovery

Project Name: Kop-Flex

Work Order #: 13121306 **Project ID:** 3705-07

Prep Batch #: 48534 **Date Prepared:** 12/18/2013 09:19 **Sample ID:** 48534-1-BKS **Matrix:** Water
Lab Batch ID: 110738 **Date Analyzed:** 12/18/2013 17:49 **Analyst:** 1034
Reporting Units: ug/L

BLANK /BLANK SPIKE RECOVERY STUDY

Dissolved Cu, Pb, Zn, Fe, Mn, Ni Analytes	Blank Result [A]	Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Control Limits %R	Flags
Copper	<1.000	40.00	35.11	88	85-115	
Iron	<100	400	386.4	97	85-115	
Lead	<1.000	40.00	36.24	91	85-115	
Manganese	<1.000	40.00	36.10	90	85-115	
Nickel	<1.000	40.00	36.62	92	85-115	
Zinc	<20.00	40.00	36.23	91	85-115	

Prep Batch #: 48489 **Date Prepared:** 12/16/2013 08:53 **Sample ID:** 48489-1-BKS **Matrix:** Water
Lab Batch ID: 110691 **Date Analyzed:** 12/17/2013 18:14 **Analyst:** 1034
Reporting Units: ug/L

BLANK /BLANK SPIKE RECOVERY STUDY

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytes	Blank Result [A]	Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Control Limits %R	Flags
Calcium	<100	500	522.1	104	85-115	
Copper	1.320	50.00	46.73	93	85-115	
Iron	<100	500	512.9	103	85-115	
Lead	<1.000	50.00	48.17	96	85-115	
Magnesium	<100	500	536.1	107	85-115	
Manganese	<1.000	50.00	50.77	102	85-115	
Nickel	<1.000	50.00	48.96	98	85-115	
Zinc	<20.00	50.00	53.27	107	85-115	

Prep Batch #: 48577 **Date Prepared:** 12/20/2013 08:37 **Sample ID:** 48577-1-BKS **Matrix:** Water
Lab Batch ID: 110794 **Date Analyzed:** 12/20/2013 13:27 **Analyst:** 1034
Reporting Units: ug/L

BLANK /BLANK SPIKE RECOVERY STUDY

Total Cu, Pb, Zn, Fe, Mn, Ni + Hardness Analytes	Blank Result [A]	Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Control Limits %R	Flags
Copper	<1.000	40.00	41.30	103	85-115	

Blank Spike Recovery [D] = 100*(([C]-[A])/[B])

H= Recovery of BS,BSD or both exceeded the laboratory control limits
F = RPD exceeded the laboratory control limits
L = Recovery of BS,BSD or both below the laboratory control limits

LCS/LCSD Recoveries

Project Name: Kop-Flex

Work Order #: 13121306
Project ID: 3705-07

Prep Batch #: 48586
Date Prepared: 12/20/2013 14:09
Sample: 48586-1-BKS
Analyst: 1044

Lab Batch ID: 110791
Date Analyzed: 12/20/2013 12:21
Method: Alkalinity_Prep / E310.2
Matrix: Water

Units: mg/L

Alkalinity Analytes	BLANK /BLANK SPIKE / BLANK SPIKE DUPLICATE RECOVERY STUDY										
	Blank Sample Result [A]	**Spike Added [B]**	**Blank Spike Result [C]**	**Blank Spike %R [D]**	**Spike Added [E]**	**Blank Spike Duplicate Result [F]**	**Blk. Spk Dup. %R [G]**	**RPD %**	**Control Limits %R**	**Control Limits %RPD**	**Flag**
Alkalinity, Total (CaCO3)	<10.00	60.00	60.69	101	60.00	61.28	102	1	90-110	20	

Relative Percent Difference RPD = 200*|(D-G)/(D+G)|
Laboratory Control Sample (LCS) Percent Recovery [D] = 100*(C)/[B]
Laboratory Control Sample Duplicate (LCSD) Percent Recovery [G] = 100*(F)/[E]

Phase Separation Science, Inc.
6630 Baltimore National Pike
Baltimore, MD 21228

H= Recovery of BS,BSD or both exceeded the laboratory control limits
F = RPD exceeded the laboratory control limits
L = Recovery of BS,BSD or both below the laboratory control limits

CHAIN OF CUSTODY RECORD

1312/306

Page 1 of 1 1 of 2

Project Number: 3705-07	Site and Location: Kop-Flex Hanover MD	
Contact Name: James Edwards	Contact Email: @wspgroup.com	
Sampler's Name: James Edwards	Sampler's Signature:	

Matrices:
S = Soil:
Aq = Water
A = Air: Bu = Bulk
W = Wipe
Bi = Biota:
OW = Oily Waste:
O = Other

Requested Analyses

Nº

	Sample Identification:	Depth	Date	Time	Matrix	Number of Containers	Total Metals	Dissolved Metals	Hardness	Alkalinity						Remarks
1,3	MW-26D	—	12-12	900	Aq	3	X	X	X	X						* Dissolved Metals
3,4	MW-21D	—	12-12	1055			X	X	X	X						Field Filtered
5,6	MW-1D	—	12-12	1555			X	X	X	X						* Metals Zn, Cu
7,8	MW-17D	—	12-13	920			X	X	X	X						Pb, Fe, Mn
9,10	MW-22D	—	12-12	1255			X	X	X	X						Only
11,12	MW-2D	—	12-11	1640			X	X	X	X						
13,14	MW-16D	—	12-11	1102			X	X	X	X						

# of Coolers: 2
Custody Seal: Abs
Ice Present: ~~5.6°C~~ ~~Ab~~ Pres
Temp: 5.6°C
Shipping Carrier: Client

Relinquished by (*Signature*):	12-13-13 11:39 Date | Time	Received by (*Signature*):	Laboratory Name: PSS
Relinquished by (*Signature*):	Date | Time	Received by (*Signature*):	Laboratory Location: Baltimore, MD
			Custody Seal Numbers: —
Turn-Around Time: Standard		Tracking Number: —	Method of Shipment: hand

WSP
WSP Environment & Energy

☒ Reston Office: 11190 Sunrise Valley Dr., #300, Reston, VA 20191 / Tel: 703-709-6500
☐ Pittsburgh Office: 750 Holiday Dr., #410, Pittsburgh, PA 15220 / Tel: 412-604-1040
☐ San Jose Office: 2025 Gateway Place, #435, San Jose, CA 95110 / Tel: 408-453-6100
☐ New Jersey Office: 200 Cottontail Ln., Somerset, NJ 08873 / Tel: 732-564-0888
☐ Denver Office: 4600 South Ulster, #930, Denver, CO 80237 / Tel: 303-850-9200
☐ Minneapolis Office: 123 North 3rd St., #808, Minneapolis, MN 55401 / Tel: 612-343-0510
☐ Woburn Office: 300 Trade Center, Suite 4690, Woburn, MA 01801
☐ Cazenovia Office: 5 Sullivan St., Cazenovia, NY 13035 / Tel: 315-655-3900

CHAIN OF CUSTODY RECORD

1312306

Page ~~1~~ 2 of ~~01~~ 2

Project Number: 3705-07	Site and Location: Kop-Flex Hanover MD	Matrices: S = Soil: Aq = Water A = Air: Bu = Bulk W = Wipe Bi = Biota: OW = Oily Waste: O = Other
Contact Name: James Edwards	Contact Email: James.Edwards@wspgroup.com	
Sampler's Name: James Edwards	Sampler's Signature:	

Requested Analyses

Nº

	Sample Identification:	Depth	Date	Time	Matrix	Number of Containers	TOC	COD								Remarks
1,2	MW-26D	—	12-12	900	Aq	2	X	X								* Hold Samples
3,4	MW-21D	—	12-12	1055			X	X								
5,6	MW-1D	—	12-12	~~420~~ 1555			X	X								
7,8	MW-17D	—	12-13	~~1255~~ 920			X	X								
9,10	MW-22D	—	12-12	1255			X	X								
11,12	MW-2D	—	12-11	1640			X	X								
13,14	MW-16D	—	12-11	1102			X	X								

# of Coolers: 2
Custody Seal: Abs
Ice Present: Pres Temp: 5.6°c
Shipping Carrier: Client

Relinquished by (*Signature*):	12-13-13 11:39 Date | Time	Received by (*Signature*):	Laboratory Name: PSS
Relinquished by (*Signature*):	Date | Time	Received by (*Signature*):	Laboratory Location: Baltimore, MD
			Custody Seal Numbers: —
Turn-Around Time: Hold		Tracking Number:	Method of Shipment: —

WSP
WSP Environment & Energy

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☐ Denver Office: 4600 South Ulster, #930, Denver, CO 80237 / Tel: 303-850-9200
☐ Minneapolis Office: 123 North 3rd St., #808, Minneapolis, MN 55401 / Tel: 612-343-0510
☐ Woburn Office: 300 Trade Center, Suite 4690, Woburn, MA 01801
☐ Cazenovia Office: 5 Sullivan St., Cazenovia, NY 13035 / Tel: 315-655-3900

Phase Separation Science, Inc

Sample Receipt Checklist

Work Order #	13121306	**Received By**	Robyn Rhudy
Client Name	WSP Environment & Energy - Restor	**Date Received**	12/13/2013 11:39:00 AM
Project Name	Kop-Flex	**Delivered By**	Client
Project Number	3705-07	**Tracking No**	Not Applicable
Disposal Date	01/17/2014	**Logged In By**	Robyn Rhudy

Shipping Container(s)

No. of Coolers	1	Ice	Present
		Temp (deg C)	5
Custody Seal(s) Intact?	N/A	Temp Blank Present	No
Seal(s) Signed / Dated?	N/A		
		Sampler Name	Not Provided N/A

Documentation

COC agrees with sample labels?	Yes
Chain of Custody	Yes

Sample Container

		Custody Seal(s) Intact?	Not Applicable
Appropriate for Specified Analysis?	Yes	Seal(s) Signed / Dated	Not Applicable
Intact?	Yes		
Labeled and Labels Legible?	Yes		

Total No. of Samples Received 14

Total No. of Containers Received 35

Preservation

Metals	(pH<2)	No
Cyanides	(pH>12)	N/A
Sulfide	(pH>9)	N/A
TOC, COD, Phenols	(pH<2)	Yes
TOX, TKN, NH3, Total Phos	(pH<2)	N/A
VOC, BTEX (VOA Vials Rcvd Preserved)	(pH<2)	N/A
Do VOA vials have zero headspace?		N/A

Comments: (Any "No" response must be detailed in the comments section below.)

For any improper preservation conditions, list sample ID, preservative added (reagent ID number) below as well as documentation of any client notification as well as client instructions. Samples for pH, chlorine and dissolved oxygen should be analyzed as soon as possible, preferably in the field at the time of sampling. Samples which require thermal preservation shall be considered acceptable when received at a temperature above freezing to 6°C. Samples that are hand delivered on the day that they are collected may not meet these criteria but shall be considered acceptable if there is evidence that the chilling process has begun such as arrival on ice.

Two coolers were received. All sample receipt conditions were acceptable. The temperatures observed were 5 and 6 degrees C.

Samples Inspected/Checklist Completed By: Robyn Rhudy Date: 12/13/2013

Robyn Rhudy

PM Review and Approval: Date: 12/20/2013

Simon Crisp

Pace Analytical Services, Inc.
9800 Kincey Ave. Suite 100
Huntersville, NC 28078
(704)875-9092

October 10, 2014

Keith Green
WSP Environmental Strategies
11190 Sunrise Valley Dr
Suite 300
Reston, VA 20191

RE: Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Dear Keith Green:

Enclosed are the analytical results for sample(s) received by the laboratory on October 03, 2014. The results relate only to the samples included in this report. Results reported herein conform to the most current TNI standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

Analyses were performed at the Pace Analytical Services location indicated on the sample analyte page for analysis unless otherwise footnoted.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Kevin Godwin
kevin.godwin@pacelabs.com
Project Manager

Enclosures

cc: Mr. James Edwards, WSP Environmental Strategies

CERTIFICATIONS

Project:	3705-02 HANOVER MD KOPFLEX
Pace Project No.:	92219888

Charlotte Certification IDs

9800 Kincey Ave. Ste 100, Huntersville, NC 28078	Florida/NELAP Certification #: E87627
North Carolina Drinking Water Certification #: 37706	Kentucky UST Certification #: 84
North Carolina Field Services Certification #: 5342	West Virginia Certification #: 357
North Carolina Wastewater Certification #: 12	Virginia/VELAP Certification #: 460221
South Carolina Certification #: 99006001	

Asheville Certification IDs

2225 Riverside Dr., Asheville, NC 28804	North Carolina Wastewater Certification #: 40
Florida/NELAP Certification #: E87648	South Carolina Certification #: 99030001
Massachusetts Certification #: M-NC030	West Virginia Certification #: 356
North Carolina Drinking Water Certification #: 37712	Virginia/VELAP Certification #: 460222

SAMPLE SUMMARY

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Lab ID	Sample ID	Matrix	Date Collected	Date Received
92219888001	**MW-05-31**	Water	10/02/14 13:23	10/03/14 10:35
92219888002	**MW-18-56**	Water	10/02/14 14:00	10/03/14 10:35
92219888003	**MW-38-28**	Water	10/02/14 17:25	10/03/14 10:35
92219888004	**TW-01-63**	Water	10/02/14 16:53	10/03/14 10:35
92219888005	**EB-100214-01**	Water	10/02/14 17:57	10/03/14 10:35

SAMPLE ANALYTE COUNT

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
92219888001	**MW-05-31**	EPA 1664B	AM1	1	PASI-C
		EPA 1664B	AM1	1	PASI-C
		EPA 6010	JMW	8	PASI-A
		EPA 6010	SH1	7	PASI-A
		SM 2540D	TEP	1	PASI-A
92219888002	**MW-18-56**	EPA 1664B	AM1	1	PASI-C
		EPA 1664B	AM1	1	PASI-C
		EPA 6010	JMW	8	PASI-A
		EPA 6010	SH1	7	PASI-A
		SM 2540D	TEP	1	PASI-A
92219888003	**MW-38-28**	EPA 1664B	AM1	1	PASI-C
		EPA 1664B	AM1	1	PASI-C
		EPA 6010	JMW	8	PASI-A
		EPA 6010	SH1	7	PASI-A
		SM 2540D	TEP	1	PASI-A
92219888004	**TW-01-63**	EPA 1664B	AM1	1	PASI-C
		EPA 1664B	AM1	1	PASI-C
		EPA 6010	JMW	8	PASI-A
		EPA 6010	SH1	7	PASI-A
		SM 2540D	TEP	1	PASI-A
92219888005	**EB-100214-01**	EPA 1664B	AM1	1	PASI-C
		EPA 1664B	AM1	1	PASI-C
		EPA 6010	JMW	8	PASI-A

ANALYTICAL RESULTS

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Sample: MW-05-31 **Lab ID: 92219888001** Collected: 10/02/14 13:23 Received: 10/03/14 10:35 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
HEM, Oil and Grease	Analytical Method: EPA 1664B							
Oil and Grease	ND	mg/L	5.0	1		10/06/14 09:22		
1664 SGT-HEM, TPH	Analytical Method: EPA 1664B							
Total Petroleum Hydrocarbons	ND	mg/L	5.0	1		10/06/14 09:25		
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum	**2280**	ug/L	100	1	10/06/14 21:20	10/07/14 18:57	7429-90-5	
Copper	**10.7**	ug/L	5.0	1	10/06/14 21:20	10/07/14 18:57	7440-50-8	
Iron	ND	ug/L	50.0	1	10/06/14 21:20	10/07/14 18:57	7439-89-6	
Lead	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 18:57	7439-92-1	
Manganese	**71.6**	ug/L	5.0	1	10/06/14 21:20	10/07/14 18:57	7439-96-5	
Nickel	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 18:57	7440-02-0	
Hardness, Total (SM 2340B)	**51900**	ug/L	662	1	10/06/14 21:20	10/07/14 18:57		
Zinc	**16.3**	ug/L	10.0	1	10/06/14 21:20	10/07/14 18:57	7440-66-6	
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum, Dissolved	**2190**	ug/L	100	1	10/06/14 18:05	10/08/14 19:34	7429-90-5	
Copper, Dissolved	**12.1**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:34	7440-50-8	
Iron, Dissolved	ND	ug/L	50.0	1	10/06/14 18:05	10/08/14 19:34	7439-89-6	
Lead, Dissolved	ND	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:34	7439-92-1	
Manganese, Dissolved	**70.3**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:34	7439-96-5	
Nickel, Dissolved	ND	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:34	7440-02-0	
Zinc, Dissolved	**25.0**	ug/L	10.0	1	10/06/14 18:05	10/08/14 19:34	7440-66-6	
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	ND	mg/L	5.1	1		10/08/14 06:14		

ANALYTICAL RESULTS

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Sample: MW-18-56 **Lab ID: 92219888002** Collected: 10/02/14 14:00 Received: 10/03/14 10:35 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
HEM, Oil and Grease	Analytical Method: EPA 1664B							
Oil and Grease	ND	mg/L	5.0	1		10/06/14 09:23		
1664 SGT-HEM, TPH	Analytical Method: EPA 1664B							
Total Petroleum Hydrocarbons	ND	mg/L	5.0	1		10/06/14 09:25		
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum	**207**	ug/L	100	1	10/06/14 21:20	10/07/14 19:16	7429-90-5	
Copper	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:16	7440-50-8	
Iron	ND	ug/L	50.0	1	10/06/14 21:20	10/07/14 19:16	7439-89-6	
Lead	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:16	7439-92-1	
Manganese	**17.6**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:16	7439-96-5	
Nickel	**8.5**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:16	7440-02-0	
Hardness, Total (SM 2340B)	**16900**	ug/L	662	1	10/06/14 21:20	10/07/14 19:16		
Zinc	**10.3**	ug/L	10.0	1	10/06/14 21:20	10/07/14 19:16	7440-66-6	
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum, Dissolved	**165**	ug/L	100	1	10/06/14 18:05	10/08/14 19:43	7429-90-5	
Copper, Dissolved	**5.7**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:43	7440-50-8	
Iron, Dissolved	ND	ug/L	50.0	1	10/06/14 18:05	10/08/14 19:43	7439-89-6	
Lead, Dissolved	ND	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:43	7439-92-1	
Manganese, Dissolved	**17.1**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:43	7439-96-5	
Nickel, Dissolved	**8.9**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:43	7440-02-0	
Zinc, Dissolved	**18.2**	ug/L	10.0	1	10/06/14 18:05	10/08/14 19:43	7440-66-6	
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**3.0**	mg/L	2.6	1		10/08/14 06:15		

ANALYTICAL RESULTS

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Sample: MW-38-28 **Lab ID: 92219888003** Collected: 10/02/14 17:25 Received: 10/03/14 10:35 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
HEM, Oil and Grease	Analytical Method: EPA 1664B							
Oil and Grease	ND	mg/L	5.0	1		10/06/14 09:23		
1664 SGT-HEM, TPH	Analytical Method: EPA 1664B							
Total Petroleum Hydrocarbons	ND	mg/L	5.0	1		10/06/14 09:25		
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum	**1930**	ug/L	100	1	10/06/14 21:20	10/07/14 19:19	7429-90-5	
Copper	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:19	7440-50-8	
Iron	**2640**	ug/L	50.0	1	10/06/14 21:20	10/07/14 19:19	7439-89-6	
Lead	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:19	7439-92-1	
Manganese	**7.7**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:19	7439-96-5	
Nickel	**151**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:19	7440-02-0	
Hardness, Total (SM 2340B)	**2920**	ug/L	662	1	10/06/14 21:20	10/07/14 19:19		
Zinc	**175**	ug/L	10.0	1	10/06/14 21:20	10/07/14 19:19	7440-66-6	
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum, Dissolved	**1400**	ug/L	100	1	10/06/14 18:05	10/08/14 19:46	7429-90-5	
Copper, Dissolved	ND	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:46	7440-50-8	
Iron, Dissolved	**2280**	ug/L	50.0	1	10/06/14 18:05	10/08/14 19:46	7439-89-6	
Lead, Dissolved	ND	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:46	7439-92-1	
Manganese, Dissolved	**7.3**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:46	7439-96-5	
Nickel, Dissolved	**147**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:46	7440-02-0	
Zinc, Dissolved	**171**	ug/L	10.0	1	10/06/14 18:05	10/08/14 19:46	7440-66-6	
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**27.3**	mg/L	4.2	1		10/08/14 06:15		

REPORT OF LABORATORY ANALYSIS

ANALYTICAL RESULTS

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Sample: TW-01-63 **Lab ID: 92219888004** Collected: 10/02/14 16:53 Received: 10/03/14 10:35 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
HEM, Oil and Grease	Analytical Method: EPA 1664B							
Oil and Grease	ND	mg/L	5.0	1		10/06/14 09:24		
1664 SGT-HEM, TPH	Analytical Method: EPA 1664B							
Total Petroleum Hydrocarbons	ND	mg/L	5.0	1		10/06/14 09:25		
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum	**723**	ug/L	100	1	10/06/14 21:20	10/07/14 19:22	7429-90-5	
Copper	**9.4**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:22	7440-50-8	
Iron	ND	ug/L	50.0	1	10/06/14 21:20	10/07/14 19:22	7439-89-6	
Lead	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:22	7439-92-1	
Manganese	**15.0**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:22	7439-96-5	
Nickel	**19.2**	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:22	7440-02-0	
Hardness, Total (SM 2340B)	**18500**	ug/L	662	1	10/06/14 21:20	10/07/14 19:22		
Zinc	**11.4**	ug/L	10.0	1	10/06/14 21:20	10/07/14 19:22	7440-66-6	
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum, Dissolved	**692**	ug/L	100	1	10/06/14 18:05	10/08/14 19:49	7429-90-5	
Copper, Dissolved	**8.4**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:49	7440-50-8	
Iron, Dissolved	ND	ug/L	50.0	1	10/06/14 18:05	10/08/14 19:49	7439-89-6	
Lead, Dissolved	ND	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:49	7439-92-1	
Manganese, Dissolved	**14.7**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:49	7439-96-5	
Nickel, Dissolved	**18.8**	ug/L	5.0	1	10/06/14 18:05	10/08/14 19:49	7440-02-0	
Zinc, Dissolved	ND	ug/L	10.0	1	10/06/14 18:05	10/08/14 19:49	7440-66-6	
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	ND	mg/L	2.5	1		10/08/14 06:15		

ANALYTICAL RESULTS

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Sample: EB-100214-01 **Lab ID: 92219888005** Collected: 10/02/14 17:57 Received: 10/03/14 10:35 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
HEM, Oil and Grease	Analytical Method: EPA 1664B							
Oil and Grease	ND	mg/L	5.0	1		10/06/14 09:24		
1664 SGT-HEM, TPH	Analytical Method: EPA 1664B							
Total Petroleum Hydrocarbons	ND	mg/L	5.0	1		10/06/14 09:25		
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Aluminum	ND	ug/L	100	1	10/06/14 21:20	10/07/14 19:25	7429-90-5	
Copper	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:25	7440-50-8	
Iron	ND	ug/L	50.0	1	10/06/14 21:20	10/07/14 19:25	7439-89-6	
Lead	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:25	7439-92-1	
Manganese	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:25	7439-96-5	
Nickel	ND	ug/L	5.0	1	10/06/14 21:20	10/07/14 19:25	7440-02-0	
Hardness, Total (SM 2340B)	ND	ug/L	662	1	10/06/14 21:20	10/07/14 19:25		
Zinc	ND	ug/L	10.0	1	10/06/14 21:20	10/07/14 19:25	7440-66-6	

QUALITY CONTROL DATA

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

QC Batch: GCSV/19089
Analysis Method: EPA 1664B
QC Batch Method: EPA 1664B
Analysis Description: 1664 HEM, Oil and Grease
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004, 92219888005

METHOD BLANK: 1300064
Matrix: Water
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004, 92219888005

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Oil and Grease	mg/L	ND	5.0	10/06/14 09:16	

LABORATORY CONTROL SAMPLE: 1300065

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Oil and Grease	mg/L	40	37.9	95	78-114	

MATRIX SPIKE SAMPLE: 1300066

Parameter	Units	92219888001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Oil and Grease	mg/L	ND	40	38.1	95	78-114	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALITY CONTROL DATA

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

QC Batch: GCSV/19090
Analysis Method: EPA 1664B
QC Batch Method: EPA 1664B
Analysis Description: 1664 SGT-HEM, TPH
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004, 92219888005

METHOD BLANK: 1300067
Matrix: Water
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004, 92219888005

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Petroleum Hydrocarbons	mg/L	ND	5.0	10/06/14 09:24	

LABORATORY CONTROL SAMPLE: 1300068

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Petroleum Hydrocarbons	mg/L	20	18.8	94	64-132	

MATRIX SPIKE SAMPLE: 1300071

Parameter	Units	92219888001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Total Petroleum Hydrocarbons	mg/L	ND	20	18.3	92	64-132	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALITY CONTROL DATA

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

QC Batch: MPRP/17056
Analysis Method: EPA 6010
QC Batch Method: EPA 3010
Analysis Description: 6010 MET
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004, 92219888005

METHOD BLANK: 1300610
Matrix: Water
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004, 92219888005

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Aluminum	ug/L	ND	100	10/07/14 18:51	
Copper	ug/L	ND	5.0	10/07/14 18:51	
Hardness, Total (SM 2340B)	ug/L	ND	662	10/07/14 18:51	
Iron	ug/L	ND	50.0	10/07/14 18:51	
Lead	ug/L	ND	5.0	10/07/14 18:51	
Manganese	ug/L	ND	5.0	10/07/14 18:51	
Nickel	ug/L	ND	5.0	10/07/14 18:51	
Zinc	ug/L	ND	10.0	10/07/14 18:51	

LABORATORY CONTROL SAMPLE: 1300611

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Aluminum	ug/L	5000	4870	97	80-120	
Copper	ug/L	500	489	98	80-120	
Hardness, Total (SM 2340B)	ug/L		31000			
Iron	ug/L	5000	4730	95	80-120	
Lead	ug/L	500	503	101	80-120	
Manganese	ug/L	500	481	96	80-120	
Nickel	ug/L	500	487	97	80-120	
Zinc	ug/L	500	485	97	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1300612 1300613

Parameter	Units	92219888001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum	ug/L	2280	5000	5000	7100	7150	96	98	75-125	1	20	
Copper	ug/L	10.7	500	500	494	500	97	98	75-125	1	20	
Hardness, Total (SM 2340B)	ug/L	51900			82000	82800				1		
Iron	ug/L	ND	5000	5000	4700	4730	93	94	75-125	1	20	
Lead	ug/L	ND	500	500	481	487	96	97	75-125	1	20	
Manganese	ug/L	71.6	500	500	543	544	94	95	75-125	0	20	
Nickel	ug/L	ND	500	500	473	476	94	95	75-125	1	20	
Zinc	ug/L	16.3	500	500	485	491	94	95	75-125	1	20	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALITY CONTROL DATA

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

QC Batch: MPRP/17055
Analysis Method: EPA 6010
QC Batch Method: EPA 3010
Analysis Description: 6010 MET Filtered
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004

METHOD BLANK: 1300593
Matrix: Water
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Aluminum, Dissolved	ug/L	ND	100	10/08/14 19:27	
Copper, Dissolved	ug/L	ND	5.0	10/08/14 19:27	
Iron, Dissolved	ug/L	ND	50.0	10/08/14 19:27	
Lead, Dissolved	ug/L	ND	5.0	10/08/14 19:27	
Manganese, Dissolved	ug/L	ND	5.0	10/08/14 19:27	
Nickel, Dissolved	ug/L	ND	5.0	10/08/14 19:27	
Zinc, Dissolved	ug/L	ND	10.0	10/08/14 19:27	

LABORATORY CONTROL SAMPLE: 1300594

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Aluminum, Dissolved	ug/L	5000	4880	98	80-120	
Copper, Dissolved	ug/L	500	487	97	80-120	
Iron, Dissolved	ug/L	5000	4890	98	80-120	
Lead, Dissolved	ug/L	500	490	98	80-120	
Manganese, Dissolved	ug/L	500	488	98	80-120	
Nickel, Dissolved	ug/L	500	489	98	80-120	
Zinc, Dissolved	ug/L	500	486	97	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1300595 1300596

Parameter	Units	92219888001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Aluminum, Dissolved	ug/L	2190	5000	5000	6710	6780	90	92	75-125	1	20	
Copper, Dissolved	ug/L	12.1	500	500	464	475	90	93	75-125	2	20	
Iron, Dissolved	ug/L	ND	5000	5000	4600	4680	91	93	75-125	2	20	
Lead, Dissolved	ug/L	ND	500	500	448	459	89	91	75-125	2	20	
Manganese, Dissolved	ug/L	70.3	500	500	522	528	90	92	75-125	1	20	
Nickel, Dissolved	ug/L	ND	500	500	450	461	89	91	75-125	2	20	
Zinc, Dissolved	ug/L	25.0	500	500	468	474	89	90	75-125	1	20	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALITY CONTROL DATA

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

QC Batch: WET/33600
Analysis Method: SM 2540D
QC Batch Method: SM 2540D
Analysis Description: 2540D Total Suspended Solids
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004

METHOD BLANK: 1301822
Matrix: Water
Associated Lab Samples: 92219888001, 92219888002, 92219888003, 92219888004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Suspended Solids	mg/L	ND	2.5	10/08/14 06:13	

LABORATORY CONTROL SAMPLE: 1301823

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Suspended Solids	mg/L	250	264	106	90-110	

SAMPLE DUPLICATE: 1301824

Parameter	Units	92219888001 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Suspended Solids	mg/L	ND	5.5		10	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALIFIERS

Project:	3705-02 HANOVER MD KOPFLEX
Pace Project No.:	92219888

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Acid preservation may not be appropriate for 2-Chloroethylvinyl ether, Styrene, and Vinyl chloride.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

LABORATORIES

PASI-A	Pace Analytical Services - Asheville
PASI-C	Pace Analytical Services - Charlotte

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 3705-02 HANOVER MD KOPFLEX
Pace Project No.: 92219888

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
92219888001	**MW-05-31**	EPA 1664B	GCSV/19089		
92219888002	**MW-18-56**	EPA 1664B	GCSV/19089		
92219888003	**MW-38-28**	EPA 1664B	GCSV/19089		
92219888004	**TW-01-63**	EPA 1664B	GCSV/19089		
92219888005	**EB-100214-01**	EPA 1664B	GCSV/19089		
92219888001	**MW-05-31**	EPA 1664B	GCSV/19090		
92219888002	**MW-18-56**	EPA 1664B	GCSV/19090		
92219888003	**MW-38-28**	EPA 1664B	GCSV/19090		
92219888004	**TW-01-63**	EPA 1664B	GCSV/19090		
92219888005	**EB-100214-01**	EPA 1664B	GCSV/19090		
92219888001	**MW-05-31**	EPA 3010	MPRP/17056	EPA 6010	ICP/15378
92219888002	**MW-18-56**	EPA 3010	MPRP/17056	EPA 6010	ICP/15378
92219888003	**MW-38-28**	EPA 3010	MPRP/17056	EPA 6010	ICP/15378
92219888004	**TW-01-63**	EPA 3010	MPRP/17056	EPA 6010	ICP/15378
92219888005	**EB-100214-01**	EPA 3010	MPRP/17056	EPA 6010	ICP/15378
92219888001	**MW-05-31**	EPA 3010	MPRP/17055	EPA 6010	ICP/15369
92219888002	**MW-18-56**	EPA 3010	MPRP/17055	EPA 6010	ICP/15369
92219888003	**MW-38-28**	EPA 3010	MPRP/17055	EPA 6010	ICP/15369
92219888004	**TW-01-63**	EPA 3010	MPRP/17055	EPA 6010	ICP/15369
92219888001	**MW-05-31**	SM 2540D	WET/33600		
92219888002	**MW-18-56**	SM 2540D	WET/33600		
92219888003	**MW-38-28**	SM 2540D	WET/33600		
92219888004	**TW-01-63**	SM 2540D	WET/33600		

Pace Analytical	**Sample Condition Upon Receipt (SCUR)**	Page 1 of 2
	Document Number: **F-CHR-CS-003-rev.15**	Issuing Authority: Pace Huntersville Quality Office

Client Name: WSP Environmental

Courier: ☑ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other________

Custody Seal on Cooler/Box Present: ☑ yes ☐ no Seals intact: ☑ yes ☐ no

Optional
Proj. Due Date:
Proj. Name:

Packing Material: ☐ Bubble Wrap ☒ Bubble Bags ☐ None ☐ Other________

Thermometer Used: IR Gun [✓ T1401] **Type of Ice:** [✓ Wet] Blue None ☑ Samples on ice, cooling process has begun

Temp Correction Factor **T1401** No Correction

Corrected Cooler Temp.: 3.8 °C **Biological Tissue is Frozen:** Yes No [✓ N/A]

Temp should be above freezing to 6°C

Date and Initials of person examining contents: MW 10-3-14

		Comments:
Chain of Custody Present:	☑ Yes ☐ No ☐ N/A	1.
Chain of Custody Filled Out:	☑ Yes ☐ No ☐ N/A	2.
Chain of Custody Relinquished:	☑ Yes ☐ No ☐ N/A	3.
Sampler Name & Signature on COC:	☑ Yes ☐ No ☐ N/A	4.
Samples Arrived within Hold Time:	☑ Yes ☐ No ☐ N/A	5.
Short Hold Time Analysis (<72hr):	☐ Yes ☑ No ☐ N/A	6.
Rush Turn Around Time Requested:	☐ Yes ☑ No ☐ N/A	7.
Sufficient Volume:	☑ Yes ☐ No ☐ N/A	8.
Correct Containers Used:	☑ Yes ☐ No ☐ N/A	9.
-Pace Containers Used:	☑ Yes ☐ No ☐ N/A	
Containers Intact:	☑ Yes ☐ No ☐ N/A	10.
Filtered volume received for Dissolved tests	☑ Yes ☐ No ☐ N/A	11.
Sample Labels match COC:	☑ Yes ☐ No ☐ N/A	12.
-Includes date/time/ID/Analysis Matrix:________		
All containers needing preservation have been checked.	☑ Yes ☐ No ☐ N/A	13.
All containers needing preservation are found to be in compliance with EPA recommendation.	☑ Yes ☐ No ☐ N/A	
exceptions: VOA, coliform, TOC, O&G, WI-DRO (water)	☑ Yes ☐ No	
Samples checked for dechlorination:	☐ Yes ☐ No ☑ N/A	14.
Headspace in VOA Vials (>6mm):	☐ Yes ☐ No ☑ N/A	15.
Trip Blank Present:	☐ Yes ☐ No ☑ N/A	16.
Trip Blank Custody Seals Present	☐ Yes ☐ No ☑ N/A	
Pace Trip Blank Lot # (if purchased):________		

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: ________________ Date/Time: ________

Comments/ Resolution: ________________

SCURF Review:	VJ	Date:	10/3/14
SRF Review:	VJ	Date:	10/6/14

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e out of hold, incorrect preservative, out of temp, incorrect containers)

Place label here

WO#:92219888

92219888

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www.pacelabs.com

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

1781957

Section A
Required Client Information:

Company: WSP
Address: 11190 Sunrise Valley Dr.
Suite 300, RESTON, VA
Email To: PAM GROFF
Phone: 703.709.6500 Fax:
Requested Due Date/TAT:

Section B
Required Project Information:

Report To: PAM.GROFF@WSPGROUP.COM
Copy To:
Purchase Order No.:
Project Name: Hanover, MD KOPFLEX
Project Number: 3705-02

Section C
Invoice Information:

Attention: Accounts Payable
Company Name: WSP
Address:
Pace Quote Reference:
Pace Project Manager:
Pace Profile #: 4362-1

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER

Site Location STATE: MD

Section D
Required Client Information

Matrix Codes MATRIX / CODE

Drinking Water	DW
Water	WT
Waste Water	WW
Product	P
Soil/Solid	SL
Oil	OL
Wipe	WP
Air	AR
Tissue	TS
Other	OT

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	COLLECTED COMPOSITE START TIME	COLLECTED COMPOSITE END/GRAB DATE	COLLECTED COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test Y/N	Oil, Grease 1664 HEM	Metals-total	Metals-field filtered	TSS	Hardness	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	MW-05-31	WT	G			10/2/14	1323		5	3		2							X	X	X	X	X		001
2	MW-18-56	WT	G			10/2/14	1400	8	5	3		2							X	X	X	X	X		002
3	MW-38-28	WT	G			10/2/14	1725	8	5	3		2							X	X	X	X	X		003
4	TW-01-63	WT	G			10/2/14	1653	8	5	3		2							X	X	X	X	X		004
5	EB-100214-01	WT	G			10/2/14	1757		3	2		1							X	X			X		005
6																									
7																									
8																									
9																									
10																									
11																									
12																									

10/2/14

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
Metals - Fe, Al, Mn, Cu, Pb, Ni, Zn	/ WSP	10/2/14	1920	Jaclyn Wilkerlace	10/3/14	1035	3.8	Y	~~N~~ Y JW 10/3/14	Y
Custody Seals: 02511, 02514, 02513, 02512										
*2 coolers in shipment										

ORIGINAL

SAMPLER NAME AND SIGNATURE
PRINT Name of SAMPLER: Pam Groff
SIGNATURE of SAMPLER:
DATE Signed (MM/DD/YY): 10/2/14

Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.07, 15-May-2007

Appendix C – WSP Field Standard Operating Procedures

FIELD STANDARD OPERATING PROCEDURE #1
Note Taking and Field Book Entries Procedure

The field book is a record of the day's activities that serves as a reference for future reporting and analyses. The field book is also a legal record for projects that may become involved in litigation. It is of the utmost importance that your notes be complete and comprehensive. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) before beginning any onsite activities.

1.1 Acronyms and Abbreviations

HASP	health and safety plan
IDW	investigation-derived waste
SOP	standard operating procedure

1.2 Materials

- Permanently-bound waterproof field book (e.g., Rite-in-the-Rain® #550, or equivalent)
- Black or blue ballpoint pen (waterproof ink recommended; do not use felt-tip pens)

1.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

The purpose of the field book is to provide a log of all of field events and conditions. The notes must include sufficient detail (i.e., who, what, when, where, why, and how) to enable others to reconstruct the day's activities for analysis, reporting, or litigation. It is important to be objective, factual, and thorough. Language must be free of personal comments or terminology that might prove inappropriate. Additional data logs or worksheets, such as low flow groundwater sampling sheets, may be used as a supplement; however, under no circumstances should the data sheets be used as a substitute for the daily record of events to be recorded in the field book.

The field book forms the foundation upon which most of the project work (reports, subsequent work plans, etc.) will be based. It is critical that field book chain of custody is maintained at all times.

1.4 Set-Up Procedures

The first step in setting up a new field book is to add the information necessary for you to identify the field book in the future and for others to return the book to WSP, should it be lost. On the first page of the field book (or, for some field books, the inside cover), place a “Return for Reward” notice. Include the following information:

- An “If Found – Return for Reward” notice in bold letters
- Our company name
- Our company address (usually the office where the project is being managed)
- Our company phone number

Reserve the second page of the field book for project-specific information, such as:

- The project name and number
- The project manager’s name
- The site telephone number, address, and onsite contact (if appropriate)
- The names and telephone numbers for all key (onsite) personnel
- The emergency telephone numbers including the police, fire, and ambulance (found in the HASP)

Business cards from individuals who visit the site, (including the person in charge of the field book) can be affixed to the inside back cover.

1.5 Field Book Entries

Start each day on a new page. Include the following information in the header of the first page (and all subsequent pages):

- The date
- The project name
- The page number (often pre-printed in Rite-in-the-Rain® style field books)

Precede field book entries by the time entered along the left margin of the page using a 24-hour or military clock (e.g., 1330 for 1:30 PM). The first entry of the day must include your and your subcontractor’s arrival time at the site, a description of the planned activities, key onsite personnel (including subcontractors), and the weather forecast. The first entry must also detail the tailgate review of the site-specific HASP with the onsite personnel. Be sure that field book entries are LEGIBLE and contain factual, accurate, and inclusive documentation of project field activities. Do not leave blank lines between field book entries. If a mistake is made in an entry, cross out the mistake with a single line and place your initials the end of the line. Any acronyms written in the field book (including your initials) must be spelled out prior to the first use. Record your initials and date at the bottom of each page.

Subsequent log entries must document the day’s activities in sequence and must be completed throughout the day as events occur (i.e., do not wait until the end of the work day to complete the notes); should out of sequence notes need to be entered, please identify using a footnote or by clearly indicating “Late Entry.” Notes must be descriptive and provide location information or diagrams (if appropriate) of the work area or sample locations. Note any changes in the weather and document all deviations from the work plan. Arrival and departure times of all personnel, and operational periods of standby, decontamination, and specific activities must be recorded.

List all field equipment used (e.g., photoionization detector, water testing equipment, personal protective equipment, etc.) and equipment calibration activities, and record field measurements, including distances, monitoring and testing instrument readings. Include the following information in entries describing sampling activities:

- The equipment and materials used by subcontractors, if appropriate (e.g., drill rig type, boring sizes, well casing materials, etc.)
- The sample media and analyses to be performed

- The sampling procedures (e.g., split-spoon sampling, hand trowel, low flow, etc.)
- The equipment used to obtain the sample (e.g., bailers, pump types, geochemical monitoring equipment, etc.)
- The sizes and types of containers, preservation (if any), and any resulting reactions
- The sample identification (especially for duplicate samples)
- The sample collection time
- The shipping and handling procedures, including chain-of-custody, air bill, and seal numbers
- If supplemental data recording logs (digital or hard copy), such as low flow groundwater sheets, the above information must be entered in the field book and the supplemental records cross-referenced.

For most sampling activities, the log entries must also include:

- The decontamination and disposal procedures for all equipment, samples, and protective clothing
- An inventory of the investigation-derived waste (IDW) materials generated during the site activities
- A description of the IDW labeling procedures and the onsite staging information

Maintain a sequential log if the sample locations and areas of interest are photographed (strongly recommended). The photographic log must include:

- The date and time of the photograph
- The sequential number of the photograph (e.g., photograph-1, photograph-2, etc.)
- The general direction faced when the photograph was made
- A description of the subject in the image

1.6 Closing Notes

The last entry of the day must include a brief wrap up of the work accomplished, a description of how the site is being secured, and a description of any near hits, accidents, and incidents that occurred during the day’s work. Draw a line through the remainder of the page from the row of text diagonally through any blank lines and initial at the end of the diagonal line.

FIELD STANDARD OPERATING PROCEDURE #4
Sample Collection and Quality Assurance Procedure

The purpose of this procedure is to assure that sample volumes and preservatives are sufficient for analytical services required under U.S. Environmental Protection Agency (EPA) or other agency approved protocols. This operating procedure describes the ways and means of selecting the appropriate sampling containers for environmental sampling. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

4.1 Acronyms and Abbreviations

ºC	degrees Celsius
COC	chain-of–custody [form]
DI	deionized water
DOT	U.S. Department of Transportation
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
HASP	health and safety plan
MS/MSD	matrix spike and matrix spike duplicate
MSA	Master Service Agreement
PPE	personal protective equipment
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
SOP	standard operating procedure
VOCs	volatile organic compounds

4.2 Materials

- Field book
- Indelible (waterproof) markers or pens
- PPE
- Sample containers
- Sample labels
- Clear tape
- Deionized (DI) water
- Cleaned or dedicated sampling equipment

4.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for collecting environmental and quality assurance samples and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), investigation derived waste management procedures (SOP 5), and equipment decontamination (SOP 6). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a site-specific work plan or a dedicated quality assurance project plan.

4.4 Sample Identification Procedures

Information on the sample labels must contain the site/project name, project/task number, unique alpha-numeric sample identification (ID) number, sample date, time of collection using the military or 24-hour clock system (e.g., 0000 to 2400 hours), analytical parameters, preservative, and sampling personnel. WSP personnel are advised to use pre-printed waterproof mailing labels (e.g., Avery® 5xxx Waterproof Address Labels) for all sample identification. WSP templates for the labels are available in each office.

The sample identification number must, unless otherwise approved by your project manager or specified in your site-specific work plan, follow the WSP naming protocol. This protocol was developed to aid in determining the type of sample collected (e.g., soil, groundwater, vapor, etc.), the sample location, and, where appropriate, the sample depth. The protocol was also designed to ensure consistency across the company.

Construct sample IDs in the following format:

SB-10A (4-6)

Where, in this example:

SB = the first two or three characters will define the sample type (see list of approved prefixes below); in this case, a soil boring

10A = the next two or three alpha-numeric digits (separated by a dash from the sample type identifier) indicate the location of the boring on the site; in this case, boring number 10A

(4-6) = the depth the sample was collected, with the first number (including decimals, if necessary) indicating the top of the sample interval and the second number indicating the bottom of the sample interval; not all sample types will include depth information.

Additional label information may be added after the last character of the sample ID (e.g., sample date, underground storage tank number, area of concern number, “Area” number, Client Identifier, etc.). Separate any additional information from the required portion of the sample name by dash(es).

Sample Prefix	Permitted Use
AA -	Ambient outdoor air samples
CC -	Concrete core/chip sample
CS -	Confirmation/verification soil samples collected from an excavation
HA -	Soil samples collected with a hand auger
IAB -	Indoor air samples – basement
IAC -	Indoor air samples – crawl space
IAF -	Indoor air samples – first floor
MW -	Soil samples collected from a monitoring well borehole or a groundwater sample collected from a monitoring well
PZ -	Groundwater samples collected from a piezometer
SB -	Soil samples collected from boreholes that will not be converted to monitoring wells
SED -	Sediment samples
SG -	Soil gas samples other than sub-slab samples (e.g., samples collected from temporary or permanent PVC sample points or stainless steel screen implants)
SL -	Sludge samples
SS -	Surface soil samples collected using hand tools (e.g., trowel, spoon, etc.) and typically at depths less than 2 feet below ground surface
SSV -	Sub-slab vapor samples
SW -	Surface water samples
TC -	Tree core samples
TP -	Soil samples collected from a test pit
WC -	Waste characterization samples
WP -	Wipe samples

4.5 Sample Containers, Preservatives, and Holding Times

The first step in sample collection is to verify that the analytical laboratory has provided the correct number and type of sample containers and each contains the appropriate preservatives for the proposed project (i.e., check against the sampling plan requirements outlined in the site-specific Quality Assurance Project Plan [QAPP]). Inspect all containers and lids for flaws (cracks, chips, etc.) before use. Do not use any container with visible defects or discoloration. Report any discrepancies, or non-receipt, of specific types of sample containers to the team leader or project manager immediately. Make arrangements with the laboratory to immediately ship missing or additional sampling containers.

Take special effort to prevent cross contamination and contamination of the environment when collecting samples. Protect equipment, sample containers and supplies from accidental contamination. Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to sampling. The gloves must not come in contact with the medium being sampled and must be changed any time during sample collection when their cleanliness is compromised. Sample collection must follow all appropriate SOPs and state and federal regulations, or guidance, for the collection of environmental samples; the recommended order of sample collection is:

- Geochemical measurements (e.g., temperature, pH, specific conductance)

- Volatile organic compounds (VOCs)
- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Total metals
- Dissolved metals
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Collected samples that require thermal preservation must be immediately (within 15 minutes) placed in a cooler with wet ice and maintained at a preservation temperature of 4° Celsius (C).

4.6 Field Quality Assurance/Quality Control Samples

Field quality assurance/quality control (QA/QC) samples include equipment blanks, trip blanks, duplicates, and split samples. The project manager or QAPP must specify the type and frequency of QA/QC sample collection. The QA/QC sample identification number must, unless otherwise approved by your project manager or specified in your site-specific work plan, follow the WSP naming protocol as discussed in the sections below. QA/QC samples must be clearly identified on WSP's copy of the COC form and in the field book. Failure to properly collect and submit required QA/QC samples can result in invalidation of an entire sampling event.

Collect, preserve, transport and document split samples using the same protocols as the related samples.

4.6.1 Equipment Blanks

Equipment blanks are used to document contamination attributable to using non-dedicated equipment. Collect equipment blanks in the field at a rate of one per type of equipment per day, unless otherwise specified. If the site-specific work plan or QAPP indicates that an equipment blank is to be collected from dedicated sampling equipment, collect the equipment blank in the field before sampling begins. If field decontamination of sampling equipment is required, prepare the equipment blanks after the equipment has been used and field-decontaminated at least once. Prepare equipment blanks by filling or rinsing the pre-cleaned equipment with laboratory provided analyte-free water and collecting the rinsate in the appropriate sample containers. The samples must be labeled, preserved, and filtered (if required) in the same manner as the environmental samples. Record the type of sampling equipment used to prepare the blank. Have the equipment blanks analyzed for all the analytes for which the environmental samples are being analyzed, unless otherwise specified. Decontamination of the equipment following equipment blank procurement is not required. If laboratory-grade DI water is unavailable, store-grade distilled water can be used to prepare these blanks. If store-grade distilled water is used, be sure to record the source and lot number in the field book. Designate equipment blanks using "EB", followed by the date, and in the order of equipment blanks collected that day. For example, the first equipment blank collected on July 4, 2013, would be designated EB070413-1.

4.6.2 Trip Blanks

Trip blanks are used to document VOC contamination attributable to shipping and field handling procedures. Trip blanks are only required when analyzing samples for VOCs. Trip blank(s) will be prepared at the laboratory and will be sent to the facility along with sample containers. Never open trip blank sample bottles, but label them in the field and return them to the laboratory in the same shipping container in which the trip blank sample bottles arrived at the site. Keep the trip blank sample bottles in the same shipping container used to ship and store VOC sample bottles during the sampling event. To minimize the number of trip blanks needed per shipment, if possible, ship all of the VOC samples in the same shipping container with the trip blank. If laboratory-provided trip blanks are not available, DI water, or store-grade distilled water and clean, empty VOC sample bottles can be used to prepare additional trip blanks. If store-grade distilled water is used, be sure to record the source and lot number in the field book. Identify trip blanks using “TB”, followed by the date. For example, the trip blank shipped with a cooler of samples on July 4, 2013, would be designated TB070413-1. If a second trip blank is needed on that same day, the designation would be TB070413-2.

4.6.3 Temperature Blank

Temperature blanks are used to determine if proper sample thermal preservation has been maintained by measuring the temperature of the sample container upon arrival at the laboratory. A temperature blank should be included in each sample cooler used to ship and store the sample bottles during the sampling event. If laboratory-provided temperature blanks are not available, fill a clean, unpreserved sample bottle with potable, DI, or store-grade distilled water and identify the bottle as a temperature blank.

4.6.4 Duplicates

Duplicates are useful for measuring the variability and documenting the precision of the sampling process. Unless more stringent project requirements are in place, collect duplicate samples at least at a rate of 1 per 20 samples collected. Under no circumstances can equipment or trip blanks be used as duplicates. Sample locations where sufficient sample volume is available and where expected contamination is present should be selected for sample duplication.

Collect each duplicate sample at the same time, from the same sample aliquot and in the same order as the corresponding field environmental sample. When collecting aqueous duplicate samples, alternately fill sample bottle sets (i.e., the actual sample bottle and the bottle to be used for the duplicate) with aqueous samples from the same sampling device. If the sampling device does not hold enough volume to fill the sample containers, fill the first container with equal portions of the sample, and pour the remaining sample into the next sample containers. Obtain additional sample volume and pour the first portion into the last sample container, and pour the remaining portions into the first containers. Continue with these steps until all containers have been filled.

Duplicate samples will be assigned arbitrary sample ID and a false collection time so that they are not identified as duplicates by the laboratory (i.e., submit the samples blind to the lab). The blind duplicate sample "location designation" will be left up to the project manager; however, in no case will "Dup" be allowed to appear in the sample name. Have the duplicate samples analyzed for the same analytes as the original sample. Be sure to record the duplicate sample ID, the false time, and the actual time of collection in the field notebook. The duplicate should also be indicated on WSP’s carbon copy of the chain-of-custody.

4.6.5 Matrix Spike and Matrix Spike Duplicates

Matrix spike and matrix spike duplicate samples, known as MS/MSD samples, are used to determine the bias (accuracy) and precision of a method for a specific sample matrix. Many of WSPs projects require the collection of MS/MSD samples; however, laboratory generated MS/MSD samples are sufficient for some projects. As required by your QAPP or site-specific work plan, collect MS/MSD samples at the required ratio; if the sampling ratio is not specified by your QAPP or site-specific work plan, collect MS/MSD samples at a rate of 1 for every 20 samples. Clearly convey the MS/MSD identity to the laboratory by adding “MS" or "MSD” after the sample name (e.g., MW-01MS) or in the comments section of the chain-of-custody. Under no circumstances can equipment or trip blanks be used as MS/MSD samples.

4.6.6 Split Samples

Split samples may be collected as a means of determining compliance or as an added measure of quality control. Unlike duplicate samples that measure the variability of both the sample collection and laboratory procedures, split samples measure only the variability between laboratories. Therefore, the laboratory samples must be subsamples of the same parent sample and every attempt must be made to ensure sample homogeneity. Collect aqueous split samples in the same manner as a duplicate sample.

Collecting split samples of soils, sediments, wastes, and sludge is not recommended because the homogenization necessary for a true split sample in these matrices is not possible.

Spilt samples should have the same sample location (e.g., MW-01, SB-03 (4-6), but differentiated from each other by inserting the laboratory analyzing or the agency/consultant collecting the sample after the sample location (e.g., MW-01-WSP and MW-01-EPA).

4.7 Custody Documentation

Sample custody protocols are used to demonstrate that the samples and sample containers were handled and transferred in such a manner as to eliminate possible tampering. Legal chain of custody (COC) begins when the pre-cleaned sample containers are dispatched to the field from the laboratory and continues through the sample analysis and eventual disposal. Maintaining custody requires that samples must be in the actual possession or view of a person who is authorized to handle the samples (e.g., sample collector, laboratory technician), secured by the same person to prevent tampering, or stored in a designated secure area.

It is a good idea to limit, to the extent possible, the number of individuals who physically handle the samples. Samples must be placed in locked storage (e.g., locked vehicle, locked storeroom, etc.) at all times when not in the possession or view of authorized personnel. Do not leave samples in unoccupied motel or hotel rooms or other areas where access cannot be controlled by the person(s) responsible for custody without first securing samples and shipping or storage containers with tamper-indicating evidence tape or custody seals

The COC form is used to trace sample possession from the time of collection to receipt at the laboratory. Although laboratories commonly supply their own COC form, it is recommended that WSP's COC be used to ensure that all necessary data are recorded. At a minimum, the COC needs to have a unique COC number, accompany all the samples, and include the following information:

- Project number, name, and location
- Sampler's printed name(s) and signature(s)
- Sample identification number
- Date and time (military time) of collection
- Sample matrix
- Total number of containers per sample
- Parameters requested for analysis including number of containers per analyte
- Remarks (e.g., irreducible headspace, field filtered sample, expected concentration range, specific turn-around time requested, etc.)
- Signatures of all persons involved in the chain of possession in chronological order
- Requested turn-around-time
- Name and location of analytical laboratory
- Custody seal numbers
- Shipping courier name and tracking information
- Internal temperature of shipping container upon shipment to laboratory, as needed
- Internal temperature of shipping container upon delivery to laboratory

- WSP contact information

Affix tamper-indicating evidence tape or seals to all storage and shipping container closures when transferring or shipping sample container kits or samples to an off-property party. Place the seal so that the closure cannot be opened without breaking the seal. Record the time, calendar date and signatures of responsible personnel affixing and breaking all seals for each sample container and shipping container. Affix new seals every time a seal is broken until continuation of evidentiary custody is no longer required.

FIELD STANDARD OPERATING PROCEDURE #5
Investigation Derived Waste Management Procedure

The purpose of this standard operating procedure (SOP) is to provide instructions for handling, storing, and managing Investigation Derived Waste (IDW) pending disposal. All IDW, which includes (but is not limited to) soil cuttings, development water, purge water, drilling fluids, decontamination fluids, personal protective equipment (PPE), and sampling equipment, must be managed in compliance with applicable or relevant and appropriate requirements. The user is advised to read the entire SOP and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

5.1 Acronyms and Abbreviations

DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
HASP	health and safety plan
IDW	investigation derived waste
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
SOP	standard operating procedure
TSCA	Toxic Substances Control Act

5.2 Materials

- Non-hazardous waste, hazardous waste, and/or polychlorinated biphenyl (PCB) labels
- Investigation derived waste (IDW) log (figure 1)
- Permanent ink marking pen, paint, stick/pen
- Sampling equipment (refer to sampling SOPs)
- Impermeable covers (e.g., tarps), as needed
- Duct tape, rope, or other material to secure tarp
- Copy of the waste manifest or bills of lading

5.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for handling, storing, and managing IDW pending disposal and assumes the user holds a current U.S. Department of Transportation (DOT) training and Resource Conservation and Recovery training (if required) certificates and is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), and equipment decontamination (SOP 6). The SOP does not cover investigation planning, DOT regulations, nor does it cover the evaluation of the analytical results. **Consult and involve WSP's compliance professionals during all phases of IDW management and disposal.**

5.4 IDW General Procedures

Nearly all intrusive field activities performed at WSP will generate solid or liquid wastes. Examples include:

Solid Wastes	**Liquid Wastes**
■ Soil Cuttings	■ Decontamination water
■ Drilling mud	■ Development water
■ Plastic sheeting	■ Drilling fluids
■ Spent carbon or filters (e.g., bag filters)	■ Purge water
■ PPE (e.g., Tyvek, gloves, respirator cartridges, etc.)	■ Soap or wash solutions
■ Disposable or dedicated sampling equipment (e.g,, bailers, hose, clamps, buckets, cartridge filters, etc.)	■ Reagents (e.g,, hexane, nitric acid, methanol, etc.)
■ Field analytical waste (HACH kits, Chlor-n-Soil kits, etc.)	

The specific procedures for dealing with these materials after the field activities have been completed will vary depending on whether the materials are considered non-hazardous, Resource Conservation and Recovery Act (RCRA) hazardous (characteristic or listed wastes), or contain PCBs at concentrations above 50 milligrams per kilogram (i.e., PCB wastes regulated under the Toxic Substances Control Act [TSCA]). The characterization of the wastes to be generated is ideally determined in conjunction with a WSP compliance professional before the field event occurs, based on previously generated data; however, in some cases, particularly for new sites, the status of the wastes may not be known. In these cases, handle IDW as hazardous waste until the status can be verified. Field personnel must consult their assigned WSP compliance professionals for assistance in proper waste characterization.

It is important to note that information contained in this SOP is based on federal regulations and interpretive guidance provided by the U.S. Environmental Protection Agency (EPA) and other federal regulatory sources; therefore, information provided in this SOP may be superseded by state or local-specific statutes or regulations. Field personnel must discuss the handling procedures with the project manager and assigned WSP compliance professional before mobilizing to the field.

5.4.1 Waste Minimization

Select investigation methods and techniques that will minimize the amount of wastes generated during field activities, particularly if the IDW is hazardous. Examples include using direct-push methods instead of hollow stem augers (to minimize soil cuttings) during a soil investigation, if appropriate, and limiting contact with the materials to reduce the amount of PPE required. Minimizing the amount of waste generated will reduce handling requirements and overall project costs, and is consistent with WSP's corporate goals for sustainability.

5.4.2 Hazardous Waste Generator Status

The hazardous waste generator requirements that pertain to a site depend on how much hazardous waste is generated at a site in a calendar month. In coordination with your assigned WSP compliance professional, determine the site's hazardous waste generator status (conditionally exempt, small, or large quantity generator) before site work begins and inform the site contact and/or client representative of the quantity of hazardous waste that will be generated as a result of its activities.

The following table provides a summary of requirements for each class of hazardous waste generator: Conditionally Exempt Small Quantity Generators (CESQGs), Small Quantity Generators (SQGs), and Large Quantity Generators (LQGs). Note that this is provided for guidance purposes only and should not substitute for close coordination with your assigned WSP compliance professional for all IDW-related activities.

	CESQGs	**SQGs**	**LQGs**
Quantity Limits	≤100 kg/month ≤1 kg/month of acute hazardous waste ≤100 kg/month of acute spill residue or soil §§261.5(a) and (e)	Between 100 - 1,000 kg/month §262.34(d)	≥1,000 kg/month >1 kg/month of acute hazardous waste >100 kg/month of acute spill residue or soil Part 262 and §261.5(e)
EPA ID Number	Not required §261.5	Required §262.12	Required §262.12
On-Site Accumulation Quantity	≤1,000 kg ≤1 kg acute ≤100 kg of acute spill residue or soil §§261.5(f)(2) and (g)(2)	≤6,000 kg §262.34(d)(1)	No limit
Accumulation Time Limits	None §261.5	≤180 days or ≤270 days (if greater than 200 miles) §§262.34(d)(2) and (3)	≤90 days §262.34(a)

	CESQGs	SQGs	LQGs
Storage Requirements	None §261.5	Basic requirements with technical standards for tanks or containers §§262.34(d)(2) and (3)	Full compliance for management of tanks, containers, drip pads, or containment buildings §262.34(a)
Sent To:	State approved or RCRA permitted/interim status facility §§261.5(f)(3) and (g)(3)	RCRA permitted/interim status facility §262.20(b)	RCRA permitted/interim status facility §262.20(b)
Manifest	Not required §261.5	Required §262.20	Required §262.20
Biennial Report	Not required §261.5	Not required §262.44	Required §262.41
Personnel Training	Not required §261.5	Basic training required §262.34(d)(5)(iii)	Required §262.34(a)(4)
Contingency Plan	Not required §261.5	Basic plan §262.34(d)(5)(i)	Full plan required §262.34(a)(4)
Emergency Procedures	Not required §261.5	Required §262.34(d)(5)(iv)	Full plan required §262.34(a)(4)
DOT Transport Requirements	Yes (if required by DOT)	Yes §§262.30-262.33	Yes §§262.30-262.33

5.5 Onsite IDW Management Procedures

Onsite handling procedures typically involve containerization of the IDW for offsite disposal at a regulated facility (RCRA hazardous waste, TSCA PCB waste, or certain non-hazardous wastes) or, in the case of certain non-hazardous wastes, onsite disposal. The procedures for each type of waste are presented below.

5.5.1 Hazardous Waste Management

If site data or generator knowledge indicates that the IDW is determined to be RCRA hazardous, the following procedures will apply:

- Place IDW in DOT-authorized containers (e.g., 55-gallon drum, roll-off container, or temporary storage tank). Before placing IDW in the containers, ensure that they are in good condition and will not leak.
- Containers must remain closed except when adding, sampling, or inspecting the material. The containers cannot be used as a work surface once waste is put in the container.
- Mark the container with an appropriate waterproof, self-adhesive RCRA hazardous waste label. The label must include the accumulation start date, a description of the contents of the container (e.g., soil cuttings, purge water, etc.), the EPA identification number, the generator name (the client or the facility, never WSP), and the

hazardous waste codes, if known. Field personnel must consult the assigned WSP compliance professional for help in properly completing the labels.

- The IDW containers must be properly closed, wiped clean, and stored in a secure onsite location (facility hazardous waste storage area if one exists) to limit access. At a minimum, place the drums on an impermeable surface (if available) in an area of limited access. If stored outside, cover the containers with a secured tarp at the end of each field day until the containers are picked up for disposal.
- Complete the IDW Logs (Figure 1) before leaving the site. Present one copy of the log to the site contact and the original to the project manager.
- Ensure that weekly inspections are conducted and the proper inspection forms for documentation are completed during the entire time the waste is stored onsite.

If the IDW is presumed to be hazardous and sampling is required to confirm its classification, it must be labeled "Hazardous Waste-Pending Analysis" and sampled for the parameters specified by the project regulatory specialist or project manager before leaving the site (see sampling SOPs). Treatment, storage, and disposal facilities will usually specify the required analysis for waste profiles (see below).

5.5.2 Polychlorinated Biphenyl Waste Management

If information exists to classify the IDW as TSCA-regulated PCB-containing IDW, the following procedures must be implemented:

- Place the PCB-containing IDW in DOT-authorized containers (55-gallon drum, roll-off container, or temporary storage tank).
- Containers must remain closed except when adding, sampling, or inspecting the material. The containers cannot be used as a work surface once waste is put in the container.
- Mark the container with an appropriate waterproof, self-adhesive yellow label with the words "Caution Contains PCBs", the "removed from service" date (the accumulation start date), and a description of the contents of the container (e.g., soil cuttings). Complete the label with the name and phone number of the WSP field personnel to contact in the event of an accident or spill. Field personnel must consult the assigned WSP compliance professional for help in properly completing the labels.
- The IDW containers must be properly closed, wiped clean, and stored in a secure PCB storage area onsite. If a PCB storage area is not available, construct a temporary PCB storage area. Cover the containers with a secured tarp at the end of each field day until the drums are picked up for disposal. Place one yellow 6" x 6" "Caution Contains PCBs" label on the outside of the tarp, and note the "Removed from service date" on the label.
- Inspect the area and the containers for leaks once every 30 days in accordance with 40 Code of Federal Regulations 761.65(c)(5) during the entire period the waste is stored onsite.
- Complete the IDW Logs (Figure 1) before leaving the site. Present one copy of the log to the site contact and the original to the project manager.

5.5.3 Onsite Non-Hazardous Waste Management

If information exists to classify the IDW as non-hazardous waste, the following procedures must be implemented only after being discussed and approved by the project manager and assigned WSP compliance professional:

- Soil can be spread around the borehole or other onsite location (with the approval of the client and in accordance with any applicable regulatory requirements), placed back in the boring or excavated test pit, or containerized and disposed of offsite.

- Groundwater and decontamination fluids can be poured onto the ground next to well to allow infiltration, or discharged to either the publically-owned treatment works or onsite wastewater treatment plant with approval of the client.
- PPE can be double bagged and deposited in the site dumpster with approval of the client and facility personnel or containerized and disposed of offsite.

If the IDW is containerized and is classified as non-hazardous, the following procedures will apply:

- Place the non-hazardous IDW in DOT-authorized containers (55-gallon drum, roll-off container, or temporary storage tank).
- Containers must remain closed except when adding, sampling, or inspecting the material. The containers cannot be used as a work surface once waste is put in the container.
- Mark the container with an appropriate waterproof, self-adhesive non-hazardous waste label. The label must include a description of the contents of the container (e.g., soil cuttings, purge water, etc.) and the generator (the client or the facility, never WSP). Field personnel must consult the assigned WSP compliance professional for help in properly completing the labels.
- Complete the IDW Logs (Figure 1) before leaving the site. Present one copy of the log to the site contact and the original to the project manager.
- The IDW containers must be properly closed, wiped clean, and stored in a secure onsite location.

5.6 Post-Field IDW Management Activities

It is important to follow-up on the management of the IDW once the field personnel have returned from the field. RCRA Hazardous and TSCA-regulated PCB-containing wastes have time limits and periodic inspection requirements to remain in compliance with state and federal regulations. The general post-field activities are listed below.

5.6.1 Waste Classification and Waste Profiles

Waste classifications and waste profiles must be reviewed and approved by WSP’s project manager, WSP compliance professional, and the client before field work begins. Waste profiles are generated based on new or existing site data (i.e., soil and groundwater results) and generator knowledge, although some disposal facilities may require additional composite or grab samples for characterization of the waste. WSP’s compliance professionals must be consulted to verify that proper waste classifications have been identified. Waste profiles for the same waste stream are generally valid for one year; ensure that no additional sampling is required to update existing waste profiles before conducting field activities.

5.6.2 Waste Disposal Oversight

Although exceptions may apply, generally, disposal of RCRA hazardous must be completed within **90 days** of the accumulation start date. If the facility is a small quantity generator, up to **180 days** is allowed for shipment. Disposal of TSCA-regulated PCB-containing IDW must generally be completed within 30 days of the “removal of service” date. WSP’s compliance professionals must be consulted to determine if any exemptions apply.

Before the IDW is removed, the waste disposal subcontractor must provide WSP with a copy of the waste profile and printed manifest for review and approval. Your assigned WSP compliance professional must review and approve these documents. WSP must have written authorization from the client on file to act **on behalf of (never “as an agent of”)** the client for waste disposal (handled on a site-by-site basis).

- The transport driver will present you with a pre-printed manifest that has been reviewed and approved by WSP. Review and verify that all information is complete and correct and that the total estimated weight of the material is written on the manifest. (Note: Manifests for PCB wastes must be completed in accordance with TSCA regulations. 40 CFR 761.207 requires that the weight of the PCBs be in kilograms and the date removed from service be on the manifest.) Remember, only a DOT-trained WSP employee is allowed to review and sign the manifest.
- Sign the manifest “On behalf of [insert client name].” Do not us “as an agent of.”
- Ensure that all containers are properly labeled and transferred to the transporting vehicle; ensure that the vehicle is properly placarded.
- Once the IDW has been removed from the site, the IDW log must be marked “Removed,” placed in the project file, and a copy must be forwarded to WSP’s DOT compliance manager.

The manifest, certificate of disposal, IDW log, and inspection reports must be maintained on file for at least 3 years.

Investigation Derived Waste Log

Date: ______________

Site Information

Site Name: ______________________________ Site EPA ID #: ____________________________

Site Contact: ______________________________ Site Address: ____________________________

Contact Telephone No: ________________________

Waste Identification:

Type of Waste Generated (check one of the following):

☐ Soil Cuttings ☐ PPE ☐ Decontamination Water

☐ Groundwater ☐ Storm Water ☐ Drilling Fluids

☐ Other (Describe): ____

Field Activities that Generated the Waste:

☐ Soil Borings ☐ Well Sampling ☐ Well Installation

☐ Decon ☐ Excavation ☐ Pumping Tests

☐ Other (Describe): ____

Generation Date: ________________________ ***90-Day Deadline***: ___________________________

Quantity of Waste Generated and Container Type:

____

____

Storage Location: ____

Waste Identification (Check One of the Following):

☐ Non Hazardous Waste (pending analysis)

☐ Non Hazardous Waste (based on site information or generator knowledge)

☐ Hazardous Waste (pending analysis)

☐ Hazardous Waste (based on site information or generator knowledge)

If generator knowledge or site information was used for identification, explain: _____________________

____

____

Type of Label Applied to Container: ☐ Non Haz ☐ Hazardous ☐ PCB ☐ Used Oil

WSP Information (Note: One copy to site contact - the original in project file)

Personnel/Contact: ________________________________ Project No.: ____________________

Telephone: ____

FIELD STANDARD OPERATING PROCEDURE #7
Water Quality Monitoring Equipment Procedure

The procedures outlined in this Standard Operating Procedure (SOP) are designed to ensure that water quality monitoring equipment is calibrated and used properly. This SOP addresses the short-term or discrete-measurement use of portable water quality monitoring equipment for the collection of physical, chemical, or biological field measurements. Common field parameters include temperature, pH, specific conductance (SC), turbidity, oxidation-reduction potential (ORP), and dissolved oxygen (DO). The user is advised to read the entire SOP and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

7.1 Acronyms and Abbreviations

DI	deionized water
DO	dissolved oxygen
°F	degrees Fahrenheit
HASP	health and safety plan
IDW	investigation derived waste
mg/l	milligrams per liter
mV	millivolts
NTU	nephelometric turbidity units
ORP	oxidation-reduction potential
PPE	personal protective equipment
QAPP	quality assurance project plan
SC	specific conductance
SDS	Safety Data Sheets
SOP	standard operating procedure
SU	standard units
µS/cm	microsiemens per centimeter

7.2 Materials

- Field book
- PPE
- Water quality meter
- Display/logger
- Communication cables
- Calibration cup or beaker
- Standard solutions, as appropriate

- Deionized water (DI) or distilled water
- Decontamination supplies

7.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for preparing water quality monitoring equipment for use and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), investigation derived waste (IDW) management procedures (SOP 5), equipment decontamination (SOP 6), groundwater sampling (SOP 11), and surface water sampling (SOP 12). This SOP does not cover the selection of water quality monitoring equipment, nor does it cover water quality monitoring equipment-specific instructions. These topics require a significant amount of planning and are more appropriately addressed in a project-specific work plan. Be sure to review the project-specific work plan or Quality Assurance Project Plan (QAPP) and any applicable state and federal guidelines or calibration procedures. The sampler should be familiar with the use and calibration of all sampling and monitoring equipment. All sampling references must be available for consultation in the field, including:

- WSP's SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer's manuals
- Project-specific work plan, HASP, and QAPP

7.4 General Equipment Handling and Management Procedures

Generally, WSP uses multi-parameter water quality meters bundled in a single housing unit (a sonde). These types of units offer a single, convenient device that is capable of measuring most or all of the parameters monitored during a typical sampling event. Individual parameter water quality meters are available and, in some cases, offer a higher degree of accuracy, although the difficulty in deploying multiple meters for most tasks relegates them to specialty use.

Field personnel must consult their assigned WSP compliance professionals for assistance in proper use, storage, and disposal of all calibration standard solutions.

The manufacturer's recommendations and instructions vary from one instrument to the next; however, all types of water quality monitoring equipment share common handling and management procedures designed to ensure the integrity of the measurements collected. Based on these procedures, the user should:

- Transport the water quality monitoring equipment in a padded case that is designed to protect the equipment; airtight cases need to be vented if using sensors that have flexible or semi-permeable membranes.
- Follow the manufacturer's instructions for assembly, operation, calibration, and maintenance specific to your equipment. The manufacturer's instructions should be followed explicitly in order to obtain accurate results.

- Follow the manufacturer's instructions for assembly, operation, calibration, and maintenance specific to your equipment. The manufacturer's instructions should be followed explicitly in order to obtain accurate results.
- Keep either the sensor guard or transportation/calibration cup installed to avoid damaging the sensors. Some sensors require a small amount of water in the transportation/calibration cup; follow the manufacturer's recommendations.
- Ensure that all equipment is in proper working condition, not damaged, and that batteries are properly charged before using the equipment for field testing measurements.
- Instruments may be sensitive to static electricity.
- Record manufacturer name and model number for each instrument used in the field book.
- Calibrate the instrument in the field, as close to the time of use as possible, and repeat at the frequency suggested by the manufacturer.
- Protect the instrument from direct sunlight, precipitation, and extremely hot or cold temperatures (e.g., do not store in vehicle).
- Store cables only after they are clean, dry, and neatly coiled – do not bend or crimp cables.
- Attach any provided storage caps. Protect cables from abrasion or unnecessary tension when in use.
- Unless otherwise instructed by the manufacturer, decontaminate water quality monitoring equipment with non-phosphate detergent solution using a small, nonabrasive brush, cotton swab or cloth, followed by a thorough DI water rinse.

7.5 Calibration Procedures

Water quality monitoring equipment must be inspected and the sensors calibrated before use. Consult the manufacturer's guidelines before beginning the calibration process and contact the manufacturer's technical support if problems or questions arise.

Conduct the following procedures to ensure proper testing and calibration and record observations in the field book:

- Inspect the sensors to be sure that they are clean, installed properly and are not damaged before calibrating and using a water quality monitoring equipment in the field.
- Complete field calibration in an area sheltered from wind, dust, and temperature/sunlight fluctuations such as inside a room or vehicle in which the ambient temperature of the standards is maintained at a temperature >40 degrees Fahrenheit (^{o}F) and < 100°F.
- Purchase appropriate, prepared standard solutions in accordance with the project-specific work plan or QAPP. Do not mix or dilute standards in the field. Allow water quality monitoring equipment to warm up for at least 10 minutes after being turned on, or for the specified time period recommended by the manufacturer.
- Record the brand, concentration, lot numbers and expiration dates of standard solutions in the field book.
- Handle standard solutions in a manner that prevents their dilution or contamination. Do not use expired standard solutions. Do not reuse standard solutions or pour solutions back into the bottle; ensure that proper chain-of-custody has been followed for standard solutions stored at a site.
- Ensure that the water quality monitoring equipment has been set to display or record the appropriate measurement unit, as available.
- Allow standard solutions to equilibrate to the temperature of the sample source, to the degree possible or as specified in the manufacturer's guidance.

- Unless otherwise instructed by the manufacturer, use the calibration cup that comes with the instrument for calibration.
- Use the recommended volume of standard solution when filling the calibration cup (e.g., the standard solution must cover the temperature sensor, as most sensors require temperature compensation).
- Be careful not to over tighten the calibration cup; many calibration cups have vents that allow their equilibration with ambient pressure.
- Rinse sensors thoroughly three times with DI water after use of each standard solution, followed by three rinses with the next standard solution to be used.
- Wait for readings to stabilize (approximately 30 seconds under normal conditions) before adjusting and saving the calibration point.
- Do not override a calibration error message without troubleshooting and correcting the cause of the error. For example, check the fluid level and check for air bubbles in the sensor. Record calibration end points and readings in the field book.
- Calibration frequency is dependent upon project specifications, instrument performance, and manufacturer's recommendations; repeat the calibration procedures as directed.
- Document the time, date, and calibration status for each instrument.
- If calibration fails to meet criteria, follow the manufacturer's instructions for corrective action to adjust instrument performance and note any indication of a substandard calibration.
- If the instrument does not start up, check out, or calibrate properly, the instrument should not be used.

7.5.1 Specific Conductance

SC, or conductivity, measures the ability of water to conduct an electric current. It is generally reported in microsiemens per centimeter (µS/cm) or millisiemens per centimeter. Natural waters, including groundwater, commonly exhibit specific conductance well below 1 µS/cm. Total dissolved solid concentrations may be approximated from specific conductance data; high readings (greater than 500 µS/cm) may indicate contamination, especially if the readings are elevated compared to background. Alternatively, elevated specific conductance may indicate inadequate well development, grout contamination, or an inadequate grout seal.

When calibrating for specific conductance:

- If not specified in the project-specific work plan, choose a SC standard solution recommended by the instrument manufacturer; otherwise, select a standard that is close in conductivity to that of the environmental water being sampled.
- The presence of air bubbles in conductivity electrodes will cause erroneous readings and incorrect calibration. Transmission lines, alternating-current electrical outlets and radio-frequency noise sources may cause interference; check with the instrument manufacturer's specifications for troubleshooting procedures.

7.5.2 Dissolved Oxygen

DO is used to assess the water quality with respect to certain metals (the amount of oxygen can control the valence state of metals) and, more typically, biological activity. Concentrations of DO in uncontaminated groundwater generally range from 1 to 4 milligrams per liter (mg/l). Erratic or elevated (greater than 4 milligrams per liter) DO readings may reflect sampling procedures that are causing excessive agitation and aeration of the water column which may affect sample results (i.e., oxidation or volatilization of dissolved compounds). Elevated DO readings may also indicate equipment maintenance issues. DO readings are sensitive to atmospheric interference and must be measured with a flow-through cell for *ex situ* measurements (i.e., those measured outside of the well itself). Select the type of DO sensor for the multi-parameter water quality meter in accordance with the project-specific work plan (i.e., the polarographic [or Clark cell] sensor or the luminescent [optical] sensor). Further discussion focuses on the more common polarographic sensor.

- Check the DO membrane for bubbles, wrinkles or tears. If necessary, install a new membrane and replace worn or stretched O-rings. Manufacturer guidance generally specifies membrane replacement should be completed at least 3 to 4 hours before use,
- Most manufacturers recommend that the sensor be allowed to equilibrate to the temperature of the water-vapor-saturated air for at least 15 minutes before calibration,
- Fill the calibration cup with less than 1/8 inch of water, or as recommended by the manufacturer.
- Remove any water droplets from the sensor without wiping the membrane. Water droplets on the sensor can cause a temperature compensation error in the DO calibration.
- Do not submerge or wet the sensor when loosely attaching the calibration cup.
- Enter the barometric pressure and wait for readings to stabilize before adjusting and saving the calibration point.

7.5.3 pH

pH is a measure of the effective concentration (or activity) of hydrogen ions and is expressed as the negative base-10 logarithm of the hydrogen-ion activity in moles per liter. Natural (uncontaminated) waters typically exhibit a pH ranging from 5 to 9 Standard Units (SU). Deviation of pH from background may indicate the presence of groundwater contamination or well construction problems.

Typically, a two-point calibration is used for pH (i.e., a zero-point and span calibration[s]):

- If not specified in the project-specific work plan, select a 7 SU buffer (zero-point) plus a second pH buffer (4 SU or 10 SU) that brackets the range of expected pH.
- If applicable, calibrate the conductivity and DO sensors before calibrating the pH sensor. This helps prevent cross-contamination of the conductivity sensor from pH buffer solutions (pH buffers have much higher conductivities than most environmental waters).
- Allow time for the pH and temperature sensors to equilibrate to the temperature of the buffer and stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the buffer manufacturer to determine the true pH of the buffer at that temperature and adjust the calibration reading to that value.
- Repeat the calibration process with the second buffer.

7.5.4 Oxidation-Reduction Potential

ORP is a numerical index of the intensity of the oxidizing or reducing conditions within an aqueous solution. Oxidizing conditions are indicated by positive potentials and reducing conditions are indicated by negative potentials; these values are frequently used when evaluating the biodegradation capacity of a system. Generally, negative potentials and low DO (less than 1 mg/l) are measured concurrently. ORP measurements are generally expressed in millivolts (mV). The ORP of natural (uncontaminated) waters typically ranges from +500 to -100 mV. ORP and reduction potential (Eh) are not equivalent. Follow the manufacturer’s instructions to calculate Eh. ORP readings are sensitive to atmospheric interference and must be measured with a flow-through cell; ORP may not be an appropriate stabilization parameter for some groundwater conditions. Avoid touching the sensors during calibration and measurement as calibration can be affected by static electricity.

A one-point calibration, at a known temperature, is used to calibrate the ORP sensor:

- Fill the calibration cup with enough standard solution (i.e., ZoBell's solution) to completely cover the temperature and ORP sensors.
- Allow time for the ORP and temperature sensors to equilibrate to the temperature of the buffer and stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the manufacturer to determine the true ORP of the solution at that temperature and adjust the calibration reading to that value.

7.5.5 Turbidity

Turbidity is the presence of suspended mineral and organic particles in a water sample. Turbid water may indicate inadequate well construction, development or improper sampling procedures, such as purging at an excessive rate that exceeds the well yield. Purging and sampling in a manner that produces low-turbidity water is particularly important when analyzing for total metals and other hydrophobic compounds, such as polychlorinated biphenyls, which may exhibit artificially elevated concentrations in high-turbidity samples due to their adsorption to colloidal material. Generally, the turbidity of *in situ* groundwater is very low (at or below 10 nephelometric turbidity units, NTUs); however, some groundwater zones may have natural turbidity higher than 10 NTUs.

Standard turbidity solutions are not necessarily interchangeable. Serious calibration errors can result from using inappropriate standards. Use only those standard turbidity solutions that are prescribed for the sensor by the instrument manufacturer.

Turbidity consists of a zero-point calibration and a span calibration(s):

- Fill the calibration cup to the reference line with DI or a zero-point standard.
- Allow time for the turbidity sensors to stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the buffer manufacturer to determine the true turbidity of the buffer and adjust the calibration reading to that value.
- Repeat the calibration process with the standard span calibration standard(s).

7.6 Equipment Use Procedures

Following calibration, use the monitoring equipment to complete the field measurement procedures directed in the project-specific work plan or QAPP.

- Charge instrument batteries per the manufacturer's instructions, as necessary.
- Ensure that instrument is warmed up and the measured value(s) on the water quality monitoring equipment are equilibrated (i.e., readings are representative of the solution, not ambient air) before recording in the field book.
- Biological growth or debris in the water can foul sensors; as possible, avoid inserting the sonde in areas that will result in having to stop and clean algae, sediment, or debris from the sensors (e.g., do not place on bottom of a well or streambed).
- If continuous monitoring is required, follow the manufacturer's instructions for performing continuous data logging events.

Monitoring should be performed at regular intervals as specified in the work plan, QAPP, and/or HASP. Record all measurements in the field book or on field forms and note any conditions that may affect the quality of the data (e.g., changes in weather or background conditions).

7.6.1 Groundwater

Field parameters are generally measured *ex situ* during well purging and development to provide an indication of when water representative of the formation is entering the well. Field parameters are typically recorded after each well volume is purged or at a periodic interval until stability criteria have been met. Field parameters may be measured *in situ* during purging by deploying a multi-parameter water quality meter downhole or lowered into a well or piezometer and collected at various depths (i.e., depth profile). Follow the instructions detailed in SOP 11 (Groundwater Sampling Procedures) for groundwater purging and sampling procedures.

7.6.1.1 Flow-through Cell Operation

A flow-through cell is used to minimize potential alteration of the water during contact with the air. A flow-through cell must be used when measuring DO or ORP under *ex situ* conditions.

- Inspect the integrity of the flow-through cell and O-rings.
- Connect the discharge tubing to the bottom of the flow-through cell using properly-sized tubing and fittings. Connect the effluent tubing to the top of the flow-through cell and secure the end of the tubing into the designated groundwater purge container.
- Shield the flow-through cell from direct sunlight to minimize changes in the temperature.
- Do not record any measurements until all the air from the flow-through cell and the effluent tubing has been displaced and the sensors have equilibrated. The presence of air bubbles in the flow-through cell will result in highly biased readings. Do not collect groundwater samples for laboratory analysis from the groundwater in the flow-through cell.

7.6.2 Surface Water

Surface water quality measurements commonly are monitored within a cross section of the surface water body to help determine the level of stratification or mixing (if the water body is moving). Typically a multi-parameter water quality meter is lowered through the water column to collect the data *in situ*. A multi-parameter water quality meter may be paired with a pressure transducer or graduated cable to record water quality changes with depth (i.e., depth profile). If strong currents exist, it may be necessary to attach the instruments to a weighted rope. After recording multiple measurements, as possible, return to the original measurement location to confirm the initial measurement; repeat as necessary. Follow the instructions detailed in SOP 12 (Surface Water Sampling Procedures) for surface water sampling procedures.

7.7 Closing Notes

Once field activities are complete, secure the site in accordance with the project-specific work plan. Decontaminate all equipment prior to departure and properly manage all PPE and IDW in conformance with applicable regulations.

FIELD STANDARD OPERATING PROCEDURE #9

Soil Sampling Procedure

The soil sampling procedures outlined in this standard operating procedure (SOP) are designed to ensure that collected soil samples are representative of current site conditions. Soil samples can be collected for onsite screening or for offsite laboratory analysis. The user is advised to read the entire SOP and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

9.1 Acronyms and Abbreviations

ºF	degrees Fahrenheit
HASP	Health and Safety Plan
IDW	investigation derived waste
PID	photoionization detector
PPE	personal protective equipment
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
SOP	standard operating procedure
USCS	Unified Soil Classification System
VOC	volatile organic compound

9.2 Materials

- Field book
- PPE
- Air quality monitoring equipment
- Utility knife
- Mixing tray or bowl
- Heavy-duty zipper-style plastic bags (quart or snack size)
- Plastic sheeting
- Expanding ruler or tape measure
- Munsell color chart
- Sampling containers and labeling/shipping supplies
- Field test kits, as needed
- Soil sampling method specific materials:
    - Stainless steel trowels, shovels, or spoons
    - Bucket augers, auger extension rods, auger handle, pipe wrenches

    - Split-spoon samplers, pipe wrenches
    - Direct push acetate liners
    - Shelby tube samplers
- Decontamination supplies

9.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for conducting soil sampling and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), utility location (SOP 2), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), investigation derived waste (IDW) management procedures (SOP 5), equipment decontamination (SOP 6), and use and calibration of sampling and monitoring equipment (SOPs 7 and 8). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a project-specific work plan. Before soil sampling, be sure to review the project-specific work plan or Quality Assurance Project Plan (QAPP) and any applicable state and federal guidelines or sampling procedures. All sampling and monitoring references must be available for consultation in the field, including:

- WSP’s SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer’s manuals
- Project-specific work plan and HASP
- QAPP

9.4 General Procedures

Soil samples are collected using a variety of techniques and equipment, depending on the type (e.g., surface, subsurface) and purpose (e.g., lithological logging, headspace evaluation, laboratory analysis) of the sampling, and most sampling events employ more than one equipment type or methodology. Subsurface soil sampling, for example, often includes sample collection from split-spoon, macro-core, or other dedicated sampling devices advanced into the subsurface. Recovered cores are often logged (using a Munsell color chart and other logging aids), screened for volatile organic compounds (VOCs) using a photoionization detector (PID), and sampled for laboratory analysis using disposable stainless steel spoons or other discrete sampling devices.

All types of soil sampling, regardless of the equipment used, share common handling and management procedures that are designed to ensure the integrity of the samples collected. These procedures include:

- The use of new, disposable or decontaminated sampling equipment
- The use and rotation of the appropriate PPE

- Selection of a suitable sampling location and staging area

Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to collection. This limits the possibility of cross-contamination from accidental contact with gloves soiled during collection of the previous sample. The gloves must not come in contact with the medium being sampled and must be changed any time during sample collection when their cleanliness is compromised. In no case should gloved hands be used as a soil sampling device: always use the appropriate spoon, trowel, or sampler to move the soil from the sampling device to the laboratory-supplied containers.

9.4.1 Equipment Selection

Collect all samples using either new, disposable equipment, such as polyethylene liners or single-use stainless steel spoons; or properly decontaminated sampling equipment, such as hand augers, split-spoon cutting shoes, or trowels. Soil sampling equipment should be selected based on the analytical requirements of the project and the project-specific conditions likely to be encountered. The equipment should be constructed of non-reactive, non-leachable materials (e.g., stainless steel, Teflon®, Teflon®-coated steel, polyethylene, polypropylene, etc.) which are compatible with the chemical constituents at the site. When choosing sampling equipment, give consideration to:

- the types of soil or fill present
- the required depth of the sample
- the volume of sample required
- the analytes of interest

Select the types of equipment and decontamination procedures based on the types of sampling to be performed and decontamination may require multiple steps or differing cleaning methods, depending on the sampling goals (see SOP 6 for decontamination procedures). In no case should disposable, single use materials (e.g., macro-core liners, soil baskets, etc.) be used to collect more than one sample.

9.4.2 Sampling Considerations

In preparing for sampling, you should perform the following activities (with all observations and measurements noted in the field book):

- Perform a quick reconnaissance of the site to identify sampling locations.
- Record the approximate ambient air temperature, precipitation, wind (direction and speed), tide, and other field conditions in the field book. In addition, any site-specific conditions or situations that could potentially affect the samples at the sample locations should be recorded.
- Record sample locations with respect to a permanent feature.
- Record a description of the sampling location.
- Survey the breathing zone around the sampling location with a PID, as necessary (see HASP), to ensure that the level of PPE is appropriate.

When sampling soil, it is important to find a suitable sampling location away from any sources of cross-contamination that could compromise the integrity of the samples. Consider the following:

- Position the sample collection area away from fuel-powered equipment, such as drill rigs or excavators, and upwind of other site activities (e.g., purging, sampling, decontamination) that could influence the sample. This is particularly important when screening samples in the field for VOCs with a PID, but should not be limited to the active sample collection.

- Store samples already collected from the field for laboratory analysis in clean containers and securely stage, if possible, in an uncontaminated area of the site.

9.5 Soil Collection

Soil samples can be collected from surface or subsurface depths, depending on the project requirements. Surface soils are generally those within 0.5 to 1 foot of the ground surface and can be collected using trowels, soil probes, or hand augers. Be aware that some states have specific definitions of what constitutes a surface soil sample. Subsurface soils are generally deeper and require specialized equipment to recover the samples. In most cases, subsurface soils will be collected using a drill rig or excavator to prevent the soil from being mixed with soils from a shallower interval.

Push or drive the method-specific sampling equipment (e.g., trowel, hand auger, hollow corers, split-spoon, direct push sampler, rotosonic core barrel sampler, excavator bucket) into the soil to the desired sampling depth using cleaned equipment. Record in the field book the depth interval through which the sampler was advanced and, if appropriate, the number of blows needed to drive the sampling device (i.e., when using a cathead-equipped drill rig; record the blows for every 6 inches the split-spoon sampler is advanced). If additional soil is needed to provide sufficient sample volume, repeat this step taking care to ensure that the same depth interval is collected during the resample. Use core catchers on the leading end of the sampler (if available) for soils that lack cohesiveness and are subject to crumbling and falling out of the sampler.

Withdraw the sampling equipment from the interval and collect sample by the safest way possible (i.e., avoid entering an excavation by collecting the sample from an excavator bucket at ground surface). Samples collected from an excavator bucket should be taken from the center of the material to ensure material is representative of the desired sampling interval.

Dedicated soil samplers recovered from the boring or, in the case of rotosonic cores, the soils themselves, should be placed on plastic sheeting noting the orientation of the sample (i.e., which end is "up") and the depth interval. Measure the length of the material recovered relative to the interval the sampler was advanced in percent notation (e.g., 75%) or as a fraction of the total length of the sample interval (e.g., [3/4] indicating 3 out of 4 feet) and record this information in the field book. If field screening for organic vapors is required, break or cut the soil core every 3 to 4 inches and quickly scan the breaks in the core material with the appropriate air quality monitoring equipment (e.g., PID). Record the readings in the field book. These measurements can be used to select appropriate soil samples for VOC or headspace analysis, if required (see procedures below).

Should any sample location require a vertical or horizontal offset from the proposed location, indicate the reason and record the actual sample location in the field book.

9.5.1 Undisturbed Soil Samples

Undisturbed soil samples collected for geotechnical parameters (e.g., porosity, permeability, etc.) generally require the use of specialized undisturbed sampling equipment (e.g., Shelby tube or sealed Geoprobe® liner) and collection procedures. The sampling device, once retrieved, is typically capped or sealed (to maintain the sample in its relatively undisturbed state), labeled with the sample name, orientation of the sample (i.e., top and bottom), depth interval, and shipped to the appropriate geotechnical laboratory. Follow sample labeling, preparation, and shipping procedures in SOPs 3 and 4.

9.5.2 Volatile Organic Compound Sampling

Analytical soil samples for VOC analysis should be collected immediately after screening with the PID to avoid loss of constituents to the atmosphere. Transfer the soil from the portion of the soil core to be sampled (usually the area where the highest PID readings were observed) directly into the sample containers; do not composite or mix soils for VOC analysis. Place the soil in the sampling container such that no headspace is present above the soil when the cover is placed on the jar. If sampling by US Environmental Protection Agency Method 5035 is required, follow manufacturer's specifications to use a closed-system sampler (e.g., Encore® samplers). Collect quality assurance/quality control (QA/QC) samples, if appropriate, in accordance with SOP 4, the project-specific work plan, and the QAPP.

9.5.3 Soil Headspace Analysis

Collect soil samples for field-based headspace analysis, if required as part of the project-specific work plan, after obtaining the sample for VOC analysis. First, examine the soil and remove coarse gravel, organic material (e.g., roots, grass, and woody material) and any other debris. Collect the sample using decontaminated or dedicated spoons or trowels and place in a heavy-duty zipper-style plastic bag and seal the bag. Label the sample indicating the sampling location, depth, and date. Shake the sample vigorously for approximately 15 seconds to disaggregate the sample and expose as much surface area of the soil as possible (to release the VOCs to the atmosphere within the bag). If necessary, warm the sample to room temperature (70º Fahrenheit, [ºF]) by placing the bag in a heated room or vehicle. This step is critical when the ambient temperature is below 32ºF.

The VOCs, if present, will volatilize into the sealed bag. Allow the bag to stand (to achieve equilibrium) for approximately 15 minutes. Carefully open the bag slightly and place the tip of the PID into the opening. Do not insert the tip of the probe into the soil material and avoid the uptake of water droplets. Record the highest PID measurement, which typically occurs within the first 2 to 5 seconds. Erratic PID responses may result from high organic vapor concentrations or elevated headspace moisture. If these conditions exist, qualify the headspace data in the field book. It is also important to record the ambient temperature, humidity, and whether moisture was present in plastic bag. Duplicate 10% of the headspace samples by collecting two samples from the same location. Generally, duplicate sample values should be consistent to ±20%. Samples collected for headspace screening cannot be retained for laboratory analysis.

9.5.4 Semi- and Non-Volatile Analytical Sample Collection

Collect remaining organic samples then inorganic samples in the following order of volatilization sensitivity:

- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Metals
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Collect soil samples for semi- and non-volatile parameters by separating clumps of soil material and mixing the soils (using stainless steel bowls and spoons, or other appropriate equipment) to a homogeneous particle size and texture. Transfer the contents to the sample container using a decontaminated or dedicated stainless steel spoon. Collect QA/QC samples in accordance with SOP 4, the project-specific work plan, and the QAPP.

If approved by the appropriate regulatory agency and specified in the project-specific work plan, composite soil samples can be collected to minimize the total number of analytical samples. Composite samples consist of equal aliquots (same sample size) of soil from each location being sampled (e.g., from each borehole or from multiple areas of a soil pile), by mixing the waste to a homogeneous particle size and texture using new or decontaminated stainless steel bowls and a stainless steel spoon or trowel. Transfer the contents to the appropriate laboratory-supplied sample container using a stainless steel spoon. Collect QA/QC samples in accordance with SOP 4 and the project-specific work plan or QAPP, if required.

If necessary, conduct field tests or screening on soils in accordance with the project-specific work plan and manufacturer's specifications for field testing equipment.

9.5.5 Sample Labeling and Preparation for Shipment

Once collected, prepare the soil samples for offsite laboratory analysis:

1. Clean the outside of the sample container, if necessary
2. Affix a sample tag or label to each sample container and complete all required information (sample number, date, time, depth interval, sampler's initials, analysis, preservatives, place of collection)
3. Place clear tape over the tag or label (if non-waterproof labels are used)
4. Preserve samples immediately after collection by placing them into an insulated cooler filled with bagged wet ice to maintain a temperature of approximately 4°Celcius
5. Record the sample designation, date, time, depth interval, and the sampler's initials in the field book and on a sample tracking form, if appropriate
6. Complete the chain-of-custody forms with appropriate sampling information, including:
    - Location
    - Sample name
    - Sample collection date and time
    - Number of sample containers
    - Analytical method
7. Complete sample packing and ship in accordance with proper procedures

Do not ship hazardous waste samples without first consulting a WSP compliance professional.

9.5.6 Soil Classification

Soil classification should be performed whenever soil samples are being collected to provide context for the analysis. WSP prefers following the Unified Soil Classification System (USCS) logging procedures as described in ATSM D2488[1] . The emphasis of soil classification in the field must be on describing the soils using ALL of the required descriptors; categorization of the USCS group name or symbol alone may not provide details about the soils that could later prove useful. Avoid geologic interpretation or the use of local formation names, which are often difficult to determine in the field without the regional framework. Record ALL of the following information for each soil type:

- Depth interval
- USCS group name
- USCS group symbol
- Color, using Munsell chart (in moist condition)
- Percent of cobbles or boulders, or both (approximate; by volume)
- Percent of gravel, sand, or fines, or all three (approximate; by dry weight)
- Particle-size range:
    - Gravel—fine, medium, coarse

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[1] Note that certain states/regulatory programs may require soil classification under a secondary system (e.g., US Department of Agriculture) or the use of hydrochloric acid to test the reaction with soil (none, weak, strong).

  - Sand—fine, medium, coarse
- Particle angularity: angular, subangular, subrounded, rounded
- Particle shape: (if appropriate) flat, elongated, flat and elongated
- Maximum particle size or dimension
- Hardness of coarse sand and larger particles
- Plasticity of fines: non-plastic, low, medium, high
- Dry strength: none, low, medium, high, very high
- Dilatancy: none, slow, rapid
- Toughness: low, medium, high
- Odor (mention only if organic or unusual)
- Moisture: dry, moist, wet

For intact samples also include:

- Consistency (fine-grained [clay] soils only): very soft, soft, firm, hard, very hard
- Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
- Cementation: weak, moderate, strong
- Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

Use the following standard descriptors for the textural percentages:

- Trace: 0 to 10%[2]
- Little: 11 to 20%
- Some: 21 to 35%
- And: 36 to 50%

Example descriptions, using the information listed above, would read as follows:

8-10’ – Well Graded Sand, SW (5YR2/6) fine- to medium-grained sand, trace medium sub-angular rounded gravel (up to 0.5” in diameter); medium dense to dense; wet with slow dilatancy; moderate solvent-like odor between 9’ and 10’.

10-12’ – Lean Clay with Gravel, CL (5YR2/6) low plasticity clay with some fine to coarse grained angular to subangular gravels (up to 0.25” in diameter) and trace fine to medium grained rounded sands, very stiff, moist with no dilatancy, no odors.

9.6 Closing Notes

Once sampling is completed, secure the boreholes/locations in accordance with the project-specific project work plan. Mark all sample locations with spray paint, stakes, or other appropriate marker for future reference.

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[2] The use of “Trace” for describing the fraction of clay soils is inappropriate for field-based logs as clay contents of less than 20% in fine-grained soils cannot be reliably determined in the field.

Decontaminate all equipment prior to departure and properly manage all PPE and IDW in conformance with applicable regulations.

FIELD STANDARD OPERATING PROCEDURE #17

Solid Waste Sampling Procedure

Solid waste sampling procedures outlined in this standard operating procedure (SOP) are designed to ensure that solid waste samples are representative of the materials from which they were collected and that they have not been altered or contaminated by the sampling and handling methods. Solid waste materials are commonly stored or staged in open (e.g., waste piles, outfalls, surface impoundments) or closed units (e.g., drums, tanks and associated ancillary equipment, containers, sumps). Solid waste samples can be collected for onsite screening or for offsite laboratory analysis. The user is advised to read the entire SOP and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

17.1 Acronyms and Abbreviations

F	Fahrenheit
HASP	health and safety plan
IDW	investigation derived waste
NAPL	non-aqueous phase liquid
PID	photoionization detector
PPE	personal protective equipment
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
SOP	standard operating procedure
VOC	volatile organic compounds

17.2 Materials

- Field book
- PPE
- Air quality monitoring equipment
- Utility knife
- Mixing tray or bowl
- Hip-waders or rubber boots, as necessary
- Aluminum foil or heavy-duty zipper-style plastic bags (quart size)
- Plastic sheeting
- Expanding ruler or tape measure
- Sampling containers and labeling/shipping supplies
- Field test kits, as needed
- Waste sampling method-specific sampling equipment and materials:

  - Stainless steel trowels, shovels, or spoons
  - Bucket augers, auger extension rods, auger handle, pipe wrenches
  - Split-spoon samplers, pipe wrenches
  - Direct push acetate liners
  - Shelby tube samplers
- Decontamination supplies

17.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for conducting waste and wastewater sampling and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), utility location (SOP 2), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), investigation derived waste (IDW) management procedures (SOP 5), equipment decontamination (SOP 6), use and calibration of all sampling and monitoring equipment (SOPs 7 and 8), and waste water sampling (SOP 18). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a project-specific work plan. Before sampling, be sure to review the project-specific work plan or Quality Assurance Project Plan (QAPP) and any applicable state and federal guidelines or sampling procedures. All sampling and monitoring references must be available for consultation in the field, including:

- WSP's SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer's manuals
- Project-specific work plan and HASP
- QAPP

17.4 General Procedures

Solid waste sampling presents a number of unique challenges for safe collection due to the potentially hazardous environment(s) where waste materials are located. Sampling of closed waste containers (e.g., drums, tanks, etc.) is considered a higher hazard risk because of the potential of exposure to toxic gases and flammable/explosive atmospheres. While opening closed waste containers for sampling purposes, monitor the breathing zone to ensure that the working environment does not contain hazardous levels of flammable/explosive gasses or toxic vapors, and follow the appropriate safety requirements stipulated in the HASP. Do not bodily enter tanks, sumps, waste containers, pipes, such as storm sewers or other drainage conveyances, during sample collection. **WSP personnel are not authorized to open closed units that are unlabeled or contain unknown contents.**

Each sampling situation will have unique set of equipment requirements and techniques. The selected procedures and equipment are project-specific and should be discussed by the project team before arriving onsite. All types of solid waste sampling, however, regardless of the equipment used, share common handling and management procedures that are designed to ensure the integrity of the samples collected. These procedures include:

- The use of new, disposable or decontaminated sampling equipment
- The use and rotation of the appropriate PPE (e.g., hip-waders or rubber boots and gloves, and Saranex or Tyvek duct-taped to nitrile gloves, etc.)
- Selection of a suitable sampling location and staging area

Collect all samples using either new, disposable equipment, or properly decontaminated sampling equipment. Solid waste sampling equipment should be selected based on the analytical requirements of the project and the project-specific conditions likely to be encountered. The equipment should be constructed of non-reactive, non-leachable materials (e.g., stainless steel, Teflon®, Teflon®-coated steel, polyethylene, polypropylene, etc.) which are compatible with the chemical constituents at the site. When choosing sampling equipment, give consideration to:

- the type and location of the waste unit
- the required depth of the sample
- the volume of sample required
- the analytes of interest

Select the decontamination procedures based on the types of sampling to be performed and media encountered; decontamination may require multiple steps or differing cleaning methods, depending on the sampling objectives and media encountered (see SOP 6 for decontamination procedures). In no case should disposable, single use materials be used to collect more than one sample.

Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to sampling. The gloves must not come in contact with the analytical samples and must be changed any time during sample collection when their cleanliness is compromised.

If possible, find a suitable sampling location by selecting an area that is away from any sources of cross-contamination that could compromise the integrity of the samples. This includes positioning the sample collection area away from fuel-powered equipment, such as drill rigs or excavators, and upwind of other site activities (e.g., purging, sampling, decontamination) that could influence the sample. Extension rods or other appropriate devices can be used, as necessary, to allow the sample to be collected at a distance (or through deeper water) to minimize the risk to the sampler.

Once you have arrived on site and are prepared to conduct the waste sampling, note all observations and measurements in the field book.

- Perform a quick reconnaissance of the site to identify sampling locations
- Record the approximate ambient air temperature, precipitation, wind (direction and speed), tidal, and other field conditions in the field book. In addition, any site-specific conditions or situations that could potentially affect the sampling should be recorded
- Describe the sampling location
- Position fuel powered equipment downwind and at least 10 feet from the sampling location; make sure that the exhaust faces downwind
- Record pertinent information about the waste unit (e.g., type, capacity, markings, condition, and contents)
- Evaluate the accessibility to the waste unit, including ladders or stairs, and ensure that proper grounding is present, if needed

- Survey around the sampling location with a photoionization detector (PID), as necessary (see HASP), to ensure that the level of PPE is appropriate
- Mark sampling locations with a stake or flag for future reference; if available, record locations with respect to a permanent feature

17.4.1 Safety Considerations

Solid waste sampling may present a number of unique challenges for safe collection. Solid waste materials are frequently heterogeneous due to the physical characteristics of the matrix (e.g., particle size, viscosity, etc.), the distribution of hazardous constituents within the matrix, or the manner in which the material was managed or disposed. Because waste often stratifies over time due to different densities of phases, settling of solids, or varying wastes constituents generated at different times, both solid and liquid waste samples may need to be collected (see SOP 18 for waste water sampling procedures). Consult and involve WSP's compliance professionals during all phases of solid waste sampling.

Caution should be exercised when sampling *in situ* wastes (e.g., soil piles) because of the potential presence of explosive/flammable gases and/or toxic vapors. Ground or sediment surface or stockpiles may not be stable and could present an engulfment hazard. Do not attempt to sample surface impoundments used to manage potentially hazardous wastes from a boat; all sampling should be conducted from the banks or piers of surface impoundments.

Caution should be exercised when sampling closed waste containers, such as sealed drums, because of the potential presence of explosive/flammable gases and/or toxic vapors. Visually inspect all waste units for the following:

- pressurization (bulging/dimples)
- crystals formed around the drum opening
- leaks, holes, stains
- labels, markings, hazardous warnings
- composition and type (steel/poly and open/bung)
- dead vegetation around drum
- condition, age, rust, potential shock sensitivity (as indicated by contents listed on waste label)
- sampling accessibility (including a determination if it qualifies as a confined space)

Waste containers showing evidence of pressurization and/or crystals should be furthered assessed to determine if remote opening is needed. If containers cannot be accessed for sampling, heavy equipment may be necessary to stage the containers before sampling. Adequate time should be allowed for the contents to stabilize after a container is handled.

A grounding strap must be used when sampling metal waste containers, such as 55-gallon steel drums, due to the potential presence of explosive/flammable gases. First attach a grounding strap, then touch the waste container opening with a gloved hand and allow an electrically conductive path to form, as appropriate. Using spark-resistant tools, slowly open the waste container (e.g., vents, pressure release valves, bung or drum ring and/or lid) to allow the unit to vent to the atmosphere. Do not attempt to use a manual bung wrench or de-header on drums that potentially contain shock-sensitive, reactive, explosive or flammable materials. Screen the breathing zone for explosive gases and toxic vapor with air monitoring instruments before commencing sampling. Once sampling is complete (re)seal the waste container in accordance with the manufacturer's instructions.

17.4.2 Sampling Considerations

When collecting solid waste samples, consider the following:

- Collect waste water samples first to avoid disturbing the bottom and suspending solid wastes or sediment in the water column
- If collecting several solid waste samples from a stream, ditch, or river, start sampling at the downstream location and progressively move upstream

17.5 Solid Waste Sample Collection Procedures

Solid waste samples should be collected in accordance with the project-specific work plan. Typical sampling equipment includes : (1) scoops or trowels, (2) corers or grab samplers (e.g., hand augers, sludge judge), (3) dredges (e.g., Ekman, Peterson, or Ponar), (4) composite liquid waste samplers, bailers, or drum thief samplers, and (5) excavating or drilling equipment (e.g., split-spoon sampler, backhoe bucket). Follow the manufacturer's operation manual for proper sampling procedures.

At the desired sampling location, clear away any accumulated surface debris. Place absorbent pads (if appropriate), sampling equipment and sample containers in a safe location near the waste that is to be sampled. If a grid system is being used to collect samples, lay out the grid according to the project-specific work plan.

Push the method-specific sampling equipment into the solid waste materials to the desired sampling depth using decontaminated or dedicated, disposable equipment. Tilt the sampling equipment at a slight angle, if necessary, to avoid losing waste materials. If a liquid sample is not required, decant liquid into a separate container or back into the vessel being sampled. If a liquid sample is required, decant any liquid directly into sample containers (see SOP 18). Record the depth interval through which the sampler was advanced in the field book. If additional sample volume is needed, repeat this step. Occasionally solid waste materials lack cohesiveness and are subject to crumbling and falling out of the sampler. The use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface; core catchers must be evaluated for compatibility with the proposed analytical program before use.

Note the state, quantity, phases, and color of the solid waste in the field book. If field screening for organic vapors is required, break or cut the waste materials and quickly scan the breaks in the material with the appropriate air quality monitoring equipment (e.g., PID). Record the readings in the field book.

17.5.1 Volatile Organic Compound Sampling

If required by the project-specific sampling plan, immediately collect samples for analysis of volatile organic compound (VOC) after screening the sample with the PID to avoid loss of the compounds to the atmosphere. Transfer the waste materials from the center portion of the sample interval to be sampled directly into the sample containers; do not composite or mix waste materials for VOC analysis. If sampling by US Environmental Protection Agency Method 5035 is required, follow manufacturer's specifications to use a closed-system sampler (e.g., Encore samplers). Collect quality assurance/quality control (QA/QC) samples in accordance with SOP 4 and the project-specific work plan or QAPP, if required.

17.5.2 Headspace Analysis

If required by the project-specific work plan, collect samples for field-based headspace analysis after obtaining the sample for VOC analysis. First, examine the contents of the sample and remove coarse gravel, organic material (e.g., roots, grass, and woody material) and any other debris. Collect the sample using decontaminated spoons or trowels and seal it in a heavy-duty zipper-style plastic bag. Label the sample indicating the sampling location, depth, and date. Shake the sample vigorously for approximately 15 seconds to disaggregate the sample and expose as much surface area of the soil as possible (to release the VOCs to the atmosphere within the bag). If necessary, warm the sample to room temperature (70º Fahrenheit, F) by placing the bag in a heated room or vehicle. This step is very important when the ambient temperature is below 32ºF.

After waiting approximately 15 minutes, carefully open the bag slightly and place the tip of the PID into the opening. Do not insert the tip of the probe into the soil and avoid the uptake of water droplets. Record the highest meter response, which typically occurs within the first 2 to 5 seconds. Erratic PID response may result from high organic vapor concentrations or elevated headspace moisture. If these conditions exist, qualify the headspace data in the field book. It is also important to record the ambient temperature, humidity, and whether moisture was present in plastic bag. Duplicate 10% of the headspace samples by collecting two samples from the same location. Generally, duplicate sample values should be consistent to plus or minus 20%. Samples collected for headspace screening cannot be retained for laboratory analysis.

17.5.3 Semi- and Non-Volatile Analytical Sample Collection

Collect remaining organic samples then inorganic samples in the following order of volatilization sensitivity:

- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Metals
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Collect solid waste samples for non-volatile parameters by separating clumps of waste material and mixing the waste to a homogeneous particle size and texture using new or decontaminated stainless steel bowls and a stainless steel spoon or trowel. Transfer the contents to the appropriate laboratory-supplied sample container using a stainless steel spoon. Collect QA/QC samples in accordance with SOP 4 and the project-specific work plan or QAPP, if required.

If approved by the appropriate regulatory agency and/or specified in the project-specific work plan, composite waste samples can be collected to minimize the number of samples to be analyzed when sampling highly contaminated areas. Using the appropriate sampling technique, collect equal aliquots (same sample size) from each location by mixing the waste to a homogeneous particle size and texture using new or decontaminated stainless steel bowls and a stainless steel spoon or trowel. Transfer the contents to the appropriate laboratory-supplied sample container using a stainless steel spoon. Collect QA/QC samples in accordance with SOP 4 and the project-specific work plan or QAPP, if required.

Interstitial water, or pore water, is the water occupying the space between solid particles. It can be isolated to provide either a matrix for toxicity testing or an indication of the concentration and partitioning of contaminants with a solid matrix. Pore water samples may be collected in the field using any available technology that will preserve the integrity of the analytes of interest during collection (e.g., lysimeter) or extracted in the laboratory from field-collected waste. The substrate type will dictate the volume of sample needed. In all cases, consult the laboratory conducting the analyses to provide estimates of the amount of sample necessary to obtain the desired quantity of pore water.

If necessary, conduct field tests or screening of waste materials in accordance with the project-specific work plan and manufacturer's specifications for field testing equipment.

17.5.4 Non-Aqueous Phase Liquid Sampling Procedures

Non-aqueous phase liquids (NAPL) are not typically collected from solid waste units. However, if NAPL samples are required, the sampling options and techniques should be discussed with the assigned WSP compliance professional and project manager to ensure that the NAPL is not considered to be a hazardous material for the purpose of shipping to the laboratory (SOP 3). Samples of NAPL should be collected using the same procedures as above and placed in the appropriate laboratory-supplied containers, packed on ice, and shipped to the analytical laboratory using procedures outlined in SOP 3.

17.5.5 Sample Labeling and Preparation for Shipment

Once collected, prepare the waste samples for offsite laboratory analysis by:

- Cleaning the outside of the sample container
- Affixing a sample tag or label to each sample container and complete all required information (sample number, date, time, sampler's initials, analysis, preservatives, place of collection)
- Placing clear tape over the tag or label (if non-waterproof labels are used)
- Preserving samples immediately after collection by placing them into an insulated cooler filled with bagged wet ice to maintain a temperature of approximately 4°Celcius
- Recording the sample designation, date, time, and the sampler's initials in the field book and on a sample tracking form, if appropriate
- Completing the chain-of-custody forms with appropriate sampling information
- Securing the sample packing and shipping in accordance with proper procedures

Do not ship hazardous waste samples without first consulting a WSP compliance professional.

17.6 Closing Notes

Once sampling is completed, secure the waste unit(s) in accordance with the project-specific project work plan. Decontaminate all equipment prior to departure and properly manage all PPE and IDW in conformance with applicable regulations.

Appendix D – Summary of Aquifer Test Results

WSP

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August 28, 2014

Derek E. Chase
Director, Environmental Affairs
Emerson Electric Co.
8000 West Florissant Ave.
St. Louis, MO 63136-8506

Re: Summary of Aquifer Testing and Results
Kop-Flex VCP Site #31, Hanover, Maryland

Dear Derek:

WSP USA Corp. has prepared this letter report describing the aquifer testing conducted at the Kop-Flex Site located at 7565 Harmans Road in Hanover, Anne Arundel County, Maryland and WSP's evaluation of the results. Groundwater pumping tests were performed on the Surficial Aquifer and Lower Patapsco Aquifer between April and May 2014. The results of the pumping tests will be used to assist in the design of extraction well systems for the hydraulic containment of volatile organic compound (VOC)-affected groundwater within these water-bearing zones at the site. Specific goals for the pumping tests included the following:

- evaluate the range of potential sustainable yields for a pumping well in the affected portion of the aquifer
- assess the hydraulic influence of groundwater withdrawal from an extraction well
- estimate the aquifer hydraulic properties

The field work was performed in accordance with the Scope of Work for Aquifer Testing, dated March 12, 2014, which is consistent with standard field hydrogeologic investigation procedures and applicable technical guidance for site investigations developed the US Environmental Protection Agency (EPA), and American Society of Testing and Materials (ASTM). This letter report provides information on the aquifer testing procedures, including the installation of pumping and observation wells for each test, and WSP's evaluation of the test data.

Aquifer Testing Procedures

General

Aquifer testing was first conducted on the Surficial Aquifer in the area immediately west of the main manufacturing building and then the deeper Lower Patapsco Aquifer in the southern portion of the site. The time period between the cessation of the drawdown phase for the first test and beginning of pumping for the second test was approximately four days. For each test, field data were gathered during pre-test (background) water level monitoring, step-drawdown testing of the groundwater extraction well, and a 72-hour constant discharge pumping test. The constant discharge test was designed to record water level changes in the aquifer during and following the cessation of groundwater pumping. Aquifer properties, particularly the hydraulic conductivity (K)/ transmissivity (T) and storativity, control the change in hydraulic head under non-steady state flow conditions. Water level readings over the duration of the constant discharge test were used to calculate the aquifer hydraulic parameters.

Well and Piezometer Installation

Surficial Aquifer

Extraction well (TW-1), two monitoring wells (MW-38 and MW-39), and two observation wells/piezometers (OW-1 and OW-2) were installed in early April 2014 for the purpose of conducting the pumping test in the Surficial Aquifer. The piezometers and monitoring well MW-39 were placed at incremental distances hydraulically cross-gradient and downgradient of TW-1, and completed within the lower portion of the thick sand unit screened by the extraction well. Monitoring well MW-38, which is paired with piezometer OW-1, was installed within the predominately fine-grained silt and clay deposits overlying the sand unit. This well was used to gather data on head changes in the fine-grained unit in response to groundwater withdrawals from the underlying sand deposits. The well and piezometer locations are shown in Figure 1, and a summary of well construction information is provided in Table 1.

The well and piezometer boreholes were installed using the rotosonic drilling method. During drilling, continuous soil cores were collected and logged from the ground surface to the borehole termination depth. Extraction well TW-1 was installed above the top of the clayey aquitard separating the Surficial and Lower Patapsco aquifers, which was encountered at a depth of approximately 63 feet below ground surface (bgs). The well was constructed of 4-inch inside diameter (ID) Schedule 40 polyvinyl chloride (PVC) casing with 30 feet of 0.020-inch horizontally slotted screen. Shallow monitoring well MW-38 was drilled to a depth of 28 feet bgs and constructed of 2-inch inside ID Schedule 40 PVC casing with 10 feet of 0.010-inch horizontally slotted screen. Monitoring well MW-39 and the two piezometers were completed at depths ranging from 50 feet to 56 feet bgs, and were constructed of 2-inch inside ID Schedule 40 PVC casing with 10 feet of 0.020-inch horizontal slotted screen. The monitoring wells and piezometers were completed at grade with a protective steel cover set in a concrete pad and fitted with a locking well cap. The extraction well was completed above grade with a protective steel cover set in a 2-foot square concrete pad. The logging and well construction information was recorded in a field notebook, and as-built diagrams were prepared for the newly installed wells and piezometers (Enclosure A).

The new wells and piezometers were developed by pumping to remove sediments and ensure effective communication between the screen and surrounding aquifer material. Turbidity, pH, temperature, and specific conductance were periodically monitored during the development process to ensure that water representative of the screened potion of the aquifer was entering the well. For wells screened in the sand unit, development continued until the discharge was relatively free of suspended sediments.
The drilling activities were conducted with clean equipment to prevent potential cross-contamination between well locations in accordance with WSPs' Standard Operating Procedures (SOPs). The drilling equipment (core barrels and temporary casing) were cleaned using a portable steam cleaner. All decontamination fluids generated during the drilling activities were contained in 55-gallon steel drums and managed with other investigation-derived waste from the well installation activities.

After completing the installation of the wells and piezometers, ground surface and top of casing elevations were surveyed to the nearest 0.01-foot by a Maryland-licensed surveyor. The horizontal locations of the wells and piezometers were also determined to the nearest 0.1 foot and referenced to the State plane coordinate system.

Lower Patapsco Aquifer

In early April 2014, a deep, double-cased extraction well (TW-2) was installed along the southern property boundary for conducting the pumping test in the Lower Patapsco Aquifer. The location of well TW-2 is shown in Figure 1 and the corresponding well construction information is provided in Table 1. The extraction well borehole was installed using the rotosonic drilling method. During the drilling, continuous soil cores were collected and logged from the ground surface to the borehole termination depth. During borehole installation, a permanent, 8-inch diameter outer steel casing was set into the clayey confining unit at a depth of 64 feet bgs and pressure grouted in place. After allowing the grout seal to cure for approximately 1.5 days, the well borehole was advanced through the remaining silt and clay deposits comprising the confining unit and into the underlying Lower Patapsco Aquifer.

Upon encountering the coarser grained deposits characteristic of this hydrogeologic unit, a depth-discrete sampling tool was placed at the bottom of the borehole and driven into the undisturbed aquifer materials using the drilling rig. After sampling the groundwater at the selected depth, the sampler was removed and the borehole extended to an appropriate depth for collection of the next sample. The drilling and groundwater sampling process continued until termination of the borehole at a depth of 156 feet bgs. A total of six depth discrete groundwater samples were collected at 10-foot intervals from the Lower Patapsco Aquifer at the TW-2 location. Groundwater was purged from the sampling equipment using a small electric submersible pump prior to collection for subsequent field screening and laboratory analysis. Hydrogeochemical parameters (temperature, pH and specific conductivity) were monitored during the purging process to ensure the sampler was collecting water representative of the aquifer system. Each groundwater sample was field screened for 1,1-Dichloroethene (DCE) and other chlorinated ethenes using the Color-Tec© method, and the field screening results recorded in a field notebook. All groundwater samples were submitted to the Phase Separation Science laboratory in Baltimore, Maryland and analyzed for VOCs using USEPA SW-846 test method 8260B.

The analytical and 1,1-DCE field screening results for the depth discrete samples collected from the well borehole are summarized in Table 2. Given the top of the Lower Patapsco Aquifer was encountered at a depth of 95 feet bgs, the sampling data indicates the majority of the VOC mass occurs from approximately 100 feet bgs to 145 feet bgs in this portion of the site. Concentrations of total chlorinated ethanes and ethenes over this depth interval ranged from 10 mircograms per liter (µg/l) to 408 µg/l. As for the compounds detected, the laboratory results are consistent with existing groundwater quality data, with 1,1-DCE being the predominant site-related VOC and noticeably lower concentrations of chlorinated compounds. The Color-Tec© screening results closely track the depth-related variations in total chlorinated VOC concentrations in the groundwater samples.

Based on the field screening results, the extraction well was installed to a depth of 145 feet bgs and constructed of 4-inch ID Schedule 40 PVC casing with 45 feet of 0.020-inch horizontally slotted screen. The well was completed approximately 2 feet above grade with a protective steel cover set in a concrete pad. The logging and well construction information recorded during the installation activities are presented in the well borehole log included in Enclosure A.

Well TW-2 was developed by pumping to remove sediments and ensure effective communication between the screen and surrounding aquifer material. Turbidity, pH, temperature, and specific conductance were periodically monitored during the development process to ensure that water representative of the screened potion of the aquifer was entering the well. Development continued until the well discharge was relatively free of suspended sediments.

The drilling and groundwater profiling activities were conducted with clean equipment to prevent potential cross-contamination within the borehole. The drilling equipment was cleaned using a portable steam cleaner. The sampling tool was decontaminated after the collection of each sample using a non-phosphating soap and water solution, followed by a tap water then distilled water rinse. All decontamination fluids generated during the drilling activities were contained in 55-gallon steel drums and managed with other investigation-derived waste from the well installation activities.

After completing the well installation, the ground surface and top of casing elevations were surveyed to the nearest 0.01-foot by a Maryland-licensed surveyor. The horizontal location of the well was also determined to the nearest 0.1 foot and referenced to the State plane coordinate system.

Surficial Aquifer Test

Pre-Test Water Level Monitoring

The background monitoring for the Surficial Aquifer test began the morning of April 21, 2014, to identify and evaluate the presence of any antecedent water level trends and external factors that may influence hydraulic heads in the aquifer. During this test phase, water level data were collected from monitoring well MW-39 and piezometers OW-1 and OW-2 screened in the sand unit, and shallow monitoring well MW-38. Water levels were measured at a very short time interval until early the morning of April 28, 2014, using pressure transducers installed in each of the above monitoring points. The transducers measure the water level, which is determined relative to atmospheric pressure, and record the readings in an electronic data logger. In addition, water levels in the extraction well and monitoring wells and piezometers in the test area were measured manually shortly before and after the background monitoring period using an electronic water-level indicator.

Step Drawdown Test

A step drawdown test was conducted on the extraction well, which consisted of applying higher incremental pumping rates and measuring the water levels in TW-1 and selected wells and piezometers at each successive rate. The objective of the step test was to determine the range of sustainable pumping rates for the extraction well, from which an appropriate rate could be selected for the constant-rate pumping test, and evaluate the response (i.e., drawdown) in the water level in the aquifer. The step drawdown test for TW-1 was conducted on April 29, 2014.

The extraction well pumping rate was varied between 5 gallons per minute (gpm) and 14 gpm by means of an in-line valve, which regulated the discharge from a constant-speed submersible pump installed in TW-1. The pumping rate for the extraction well was monitored throughout each step using an in-line flow meter to ensure there were no erratic changes in the well discharge. A constant extraction rate was maintained throughout each pumping step. The groundwater discharge was routed to a pair of weir tanks placed a short distance north of well TW-1. The water was then transferred to another weir tank located near the southeastern portion of the manufacturing building. Water placed into this tank was treated using granular activated carbon (GAC) to remove chlorinated VOCs and ion exchange resin to remove trace metals (particularly copper) and then discharged to the storm water sewer inlet near the southeast building corner. The water entering the storm water sewer eventually discharged to Stony Run at Outfall 001 in accordance with the facility's National Pollutant Discharge Elimination System (NPDES) Permit MD0069094 and State Discharge Permit No. 07-DP-3442.

Water levels were measured in extraction well TW-1, piezometers OW-1 and OW-2, and monitoring well MW-18 using data logging pressure transducers. The pressure transducers were programmed to collect water level data on a logarithmic scale, which allows for more rapid measurements at the beginning of the test than near the end of the test. Manual measurements using an electronic water level indicator were also made in TW-1 during the test to gather real-time data on the water level in the well and ensure no damage to the pump due to excessive drawdown during pumping.

Constant Discharge Rate Test

The constant-rate pumping test consisted of the continuous extraction of groundwater from extraction well TW-1 at the selected pumping rate (11 gpm) continuously for approximately 3 days. The constant-rate test began on the morning of April 29, 2014, approximately 17 hours following the completion of the step drawdown test. WSP field personnel regularly measured the discharge rate from the extraction well using the in-line flow meter. The management and disposal of well discharge from the constant rate test was identical to the process described for the step drawdown test.

Data logging pressure transducers were placed in the extraction well (TW-1), piezometers OW-1 and OW -2, and monitoring wells MW-18, MW-38, and MW-39. The pressure transducers were programmed to collect and record water levels on a logarithmic scale. Manual water level measurements were also made in TW-1 during the test to ensure no decrease in well yield and associated increase in drawdown during pumping. In addition, manual water level measurements were periodically collected at monitoring wells shallow well MW-5 and intermediate well MW-14 (see Figure 1 for locations of these wells).

Groundwater discharge samples were collected two times during the constant discharge rate test:

- April 29, 2014, after an elapsed pumping time of two hours
- May 2, 2014, after an elapsed pumping time of approximately 71 hours

The groundwater samples were collected in pre-preserved, 40-ml glass vials and submitted to the Phase Separation Science laboratory in Baltimore, Maryland. Both samples were analyzed for VOCs using USEPA SW-846 Test Method 8260B and 1,4-dioxane using modified USEPA method 8260B with selective ion monitoring (SIM).

Water level recovery data were collected at the extraction well, piezometers, and monitoring wells containing pressure transducers immediately after completing the drawdown phase of the test. The recovery portion of the test was started the morning of May 2, 2014, and continued until the water levels in the extraction and observation wells were changing at a rate of less than 0.1 feet per hour. The recovery phase of the test was stopped after 23.5 hours.

Lower Patapsco Aquifer Test

Pre-Test Water Level Monitoring

The background monitoring for the Lower Patapsco Aquifer test began around noon on May 1, 2014, to identify and evaluate the presence of any antecedent water level trends and external factors influencing hydraulic heads in the aquifer. During this test phase, water level data were collected from extraction well TW-2, the MW-17/MW-17D well pair, and monitoring well MW-21D. Water levels were measured at a short time interval until the morning of May 5, 2014, using pressure transducers installed in each of the above monitoring points. The transducers measured the water level, which is determined relative to atmospheric pressure, and record the readings in an electronic data logger. In addition, water levels in the extraction well and intermediate and deep monitoring wells in the test area were measured manually before and after the background monitoring period using an electronic water-level indicator.

Step Drawdown Test

A step drawdown test was conducted on the extraction well, which consisted of applying higher incremental pumping rates and measuring the water levels in TW-2 and selected monitoring wells at each successive rate. The objective of the step test was to determine the range of sustainable pumping rates for TW-2, from which an appropriate rate could be selected for the constant discharge rate test, and evaluate the response (i.e., drawdown) in the water level in the aquifer. WSP conducted the step drawdown test for TW-2 on May 5, 2014.

The extraction well pumping rate was varied between approximately 22 gpm and 44 gpm by means of an in-line valve, which regulated the discharge from a constant-speed electric submersible pump. The pumping rate for the extraction well was monitored throughout each step using an in-line flow meter to ensure there were no erratic changes in the well discharge. A constant extraction rate was maintained throughout each pumping step. The TW-2 discharge was routed to the weir tank located near the southeastern portion of the manufacturing building. Water placed into this tank was treated using GAC media to remove chlorinated VOCs, and then discharged to the storm water sewer inlet near the southeast building corner. This water eventually discharged to Stony Run in accordance with the facility's NPDES Permit MD0069094 and State Discharge Permit No. 07-DP-3442.

Water levels were measured in TW-2 and deep monitoring wells MW-1D, MW-17D, MW-21D, and MW-22D using data logging pressure transducers. The pressure transducers were programmed to collect water level data on a logarithmic scale, which allows for more rapid measurements at the beginning of the test than near the end of the test. Manual measurements using an electronic water level indicator were also made in TW-2 during the test to gather real-time data on the water level in the well and ensure no damage to the pump due to excessive drawdown during pumping.

Constant Discharge Rate Test

The constant-rate pumping test consisted of the continuous withdrawal of groundwater TW-2 at the selected pumping rate (38 gpm) continuously for approximately 3 days. The constant-rate test began in the late morning of May 6, 2014, approximately 17.5 hours following the completion of the step drawdown test. WSP field personnel regularly measured the discharge rate from the extraction well using the in-line flow meter. The management and disposal of well discharge from the constant rate test was identical to the process described for the step drawdown test.

Data logging pressure transducers were used to collect water level data from TW-2, and monitoring wells MW-1D, MW-21D, MW-22D, MW-24D, and the MW-17/MW-17D well pair. The pressure transducers were programmed to collect and record water levels on a logarithmic scale. Manual water level measurements were also made in TW-2 during the test to real-time monitor the well yield and associated drawdown in the well during pumping. In addition, manual water level measurements were periodically collected at monitoring wells intermediate wells MW-12 and MW-14, and deep wells MW-16D and MW-26D (see Figure 1 for locations of these wells).

Groundwater discharge samples were collected at two times during the constant discharge rate test:

- May 6, 2014, after an elapsed pumping time of approximately two hours
- May 9, 2014, after an elapsed pumping time of 68.5 hours

The groundwater samples were collected in pre-preserved, 40-ml glass vials and submitted to the Phase Separation Science laboratory in Baltimore, Maryland. Both samples were analyzed for VOCs using USEPA SW-846 Test Method 8260B and 1,4-dioxane using modified USEPA method 8260B with SIM.

Water level recovery data were collected at the extraction and monitoring wells containing pressure transducers immediately after completing the drawdown phase of the test. The recovery portion of the test was started the morning of May 9, 2014, and continued until the water levels in the wells were changing at a rate of less than 0.1 feet per hour. The recovery phase of the test was stopped after 24 hours.

Aquifer Test Data Analysis

Groundwater Levels under Non-Pumping Conditions

Surficial Aquifer

The background monitoring data collected before performing the constant-rate test were evaluated to determine the presence and magnitude of any antecedent water level trends and external factors that may influence hydraulic heads in the aquifer, particularly in the thick sand unit screened TW-1. Figure 2 presents a hydrograph for well MW-39 during the monitoring period along with barometric pressure readings measured at the Thurgood Marshall-Baltimore Washington International (BWI) Airport a short distance north of the Kop-Flex facility. The inverse relationship between the water level and pressure, which is typical of the wells and piezometers screened in the sand unit, indicates a barometric pressure effect on the observed groundwater fluctuations in the well. (This phenomenon also appears to influence the hydraulic head in wells completed in the shallow silt and clay deposits, although the affect is noticeably subdued.) Evaluation of the background monitoring data indicates the following median barometric efficiencies for the wells and piezometers screened in the sand unit:[1]

- MW-39 – 0.25
- OW-1 – 0.42
- OW-2 – 0.27

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[1] Barometric efficiency is defined as the water level change caused by a barometric pressure change divided by that barometric pressure change.

The barometric pressure recorded at Marshall-BWI Airport during the pumping test activities decreased 0.52 inches of mercury (in. Hg) or 0.59 ft. of water (1 in of Hg = 1.13 ft. of water). Based on the barometric efficiencies provided above, the water level increase associated with this decline in the barometric pressure would have ranged from 0.15 ft. to 0.25 ft. Since the barometric pressure-related water level change is an order of magnitude less than the apparent drawdown in the observation points, the data collected during the constant discharge rate test were not corrected for barometric pressure effects.

Lower Patapsco Aquifer

A hydrograph of the background water level and barometric pressure data for monitoring well MW-17D is provided in Figure 3. As with the intermediate-depth wells in the Surficial Aquifer, the antithetic relationship between the groundwater elevation and pressure is indicative of a barometric pressure effect on the water level in this and other deep wells. The presence of barometric pressure-related water level changes is a common hydrologic phenomenon in aquifers under confined (or artesian) conditions. Using the background monitoring data, the median barometric efficiency for wells screened in the Lower Patapsco Aquifer was determined to be 0.23. During the constant rate test, the barometric pressure recorded at Marshall-BWI Airport increased 0.36 in. of Hg, or 0.41 ft. of water, during the first day of pumping. Based on the aforementioned site-specific barometric efficiency for the aquifer, the water level decrease associated with this rise in barometric pressure would have been less than 0.1 ft. Since the barometric pressure-related water level change is more than an order of magnitude less than the apparent drawdown in the observation points, the data collected during the constant discharge rate test were not corrected for barometric pressure effects.

In addition to the barometric pressure effects, a generally decreasing trend in the water levels appeared to be superimposed with other water level fluctuations in the wells screened in the Lower Patapsco Aquifer (Figure 3). Linear regression analysis was used to estimate the rate of the potentiometric surface decline during the background monitoring period, which determined to be -0.05 feet per day (ft/day). Both the drawdown and recovery data obtained from the deep wells during the constant discharge rate pumping test were adjusted for this local antecedent rate of hydraulic head decline in the aquifer.

Hydraulic Influence during Groundwater Withdrawal

Surficial Aquifer

The start of the drawdown phase of the constant discharge rate test coincided with the occurrence of an anomalous storm event in the mid-Atlantic region. A review of the precipitation records from the Marshall-BWI Airport weather station indicated a total of 8.1 inches of rainfall over a 36-hour period from mid-morning on April 29th through mid-evening on April 30th. Water level data collected from well MW-14, which was situated near the limit of hydraulic influence for the test, indicate a gradual increase in the groundwater surface from 715 minutes (approximately 12 hours) to 2,225 minutes (approximately 37 hours) of elapsed pumping time. The total rise of the water level in this well during and immediately following the storm event is estimated to be 0.90 feet. Although background monitoring identified the presence of barometric pressure effects on hydraulic heads, the observed change in the groundwater surface during the constant rate test was linked to the significant precipitation event in the region. Consequently, the time-drawdown data measured during the test were corrected for recharge associated with the infiltration of soil moisture from the storm. Figure 4 provides a typical plot of both the measured (uncorrected) and recharge corrected drawdown for the intermediate-depth wells and piezometers during the pumping phase of the test.

The corrected drawdown at the extraction well, and monitoring wells and piezometers, after an elapsed pumping time of approximately three days, is illustrated in Figure 5. (The aquifer drawdown in the immediate vicinity of well TW-1 was determined from the water level measured in the well casing and a well efficiency of 75 percent.) A relatively large area of hydraulic influence was created within the sand unit at the selected test pumping rate of 11 gpm, as evidenced by more than 2 feet of drawdown in observation points located greater than 100 feet from the extraction well. In addition to the noticeable hydraulic response in the coarse grained deposits, drawdown of greater than one foot was also measured in shallow monitoring wells MW-5 and MW-38 in the test area (Figure 5). The appreciable displacement of the water level in these wells completed in the finer grained deposits suggests the underlying sand unit may be characterized as a leaky confined hydrogeologic unit.

The Hantush-Jacob solution was used to analyze the drawdown data from OW-1 and OW-2 after three days of pumping. Assuming steady-state flow in a leaky confined aquifer, zero drawdown would occur at an estimated radial distance of approximately 350 feet from the pumping well. However, this radius of influence at the test withdrawal rate of 11 gpm should be considered approximate due to relatively large amount of drawdown in the groundwater surface in the overlying silt and clay deposits.

Lower Patapsco Aquifer

The adjusted drawdown at TW-2 and surrounding monitoring wells shortly before the termination of pumping for the constant rate test is shown in Figure 6. (The aquifer drawdown in the immediate vicinity of TW-2 was determined from the water level measured in the well casing and a well efficiency of 75 percent.) As with the constant discharge rate test in the Surficial Aquifer, a large area of hydraulic influence was created within the upper portion of the aquifer at the selected test withdrawal rate of 38 gpm. Drawdown in the potentiometric surface of greater than 1.5 feet was detected in observation points located more than 400 feet from the extraction well. Based on the drawdown contours depicted in Figure 6, the cone of depression around the extraction well appears to form a slightly ellipsoidal area with the long (major) axis oriented in a generally east-west direction.

Plots of the corrected drawdown *vs.* time for the deep monitoring wells are consistent with aquifers characterized by a leaky or semi-confined condition. Although water level data collected from the intermediate-depth monitoring wells (MW-12, MW-14, and MW-17) indicate less than 0.2 feet of drawdown during the pumping portion of the test, these values do not take into consideration the effects of the increased recharge associated with the major storm event the week of April 27, 2014. In addition, a review of the data plots indicates a slight reduction in the observed drawdown after approximately two days of continuous pumping which may reflect enhanced transient leakage associated with the precipitation event. The measured drawdown in the deep wells during groundwater withdrawal supports the existing conceptual hydrogeologic model of the site, which indicates some limited hydraulic communication across the Lower Patapsco confining unit at a depth of approximately 60 feet bgs. For purposes of the pumping test data analysis, the Lower Patapsco Aquifer can be considered a semi-confined aquifer.

An analysis was performed on the late time drawdown data from monitoring wells located at radial distances of greater than 100 feet from TW-2 using the Theim solution for confined aquifers. Assuming steady state flow, the radial extent of hydraulic influence (i.e., zero drawdown) from the pumping well is estimated to be approximately 675 feet at a pumping rate of 38 gpm. The apparent radius of influence should be considered approximate because this solution method assumes a fully penetrating extraction well whereas TW-2 only partial penetrates the Lower Patapsco Aquifer.

Maximum Sustainable Well Yield

Surficial Aquifer

The step drawdown test conducted on April 28, 2014, was performed to evaluate the sustainable yield from the thick sand unit while pumping from well TW-1. Based on the measured drawdown in the test well during the various pumping steps, an extraction rate of 12-13 gpm is believed to approximate the maximum short term yield for an extraction well that fully penetrates this transmissive hydrogeologic unit. However, further evaluation of the water level and pumping rate data obtained during the constant rate test indicates the long term yield for an extraction well may be significantly less due to the limited available drawdown. Based on the constant discharge rate test data, the specific capacity, or yield per unit of well drawdown, of TW-1 is 1.2 gpm per foot (gpm/ft). Studies have consistently demonstrated the specific capacity of a continuously pumping well will decrease between 35 percent and 50 percent after one year as the water removed is derived primarily from aquifer storage. Assuming a conservative reduction of 50 percent, the long term specific capacity for the extraction well would then decrease to 0.6 gpm/ft. Based on the hydrogeologic data, a maximum drawdown of 12 feet would be possible in the well and still maintain a leaky confined condition for the sand unit. Based on this available drawdown, the long term sustainable yield for a well screened in the sand deposits is:

$$(0.60 \text{ gpm/ft}) \times (12 \text{ ft}) = 7.2 \text{ gpm}$$

The continuous, long term withdrawal of groundwater at rates up to 7 gpm would ensure radial flow to the extraction well under a leaky confined condition, with the potentiometric surface remaining above the upper boundary for the sand unit.

Lower Patapsco Aquifer

Evaluation of the sustainable yield for an extraction well screened in the upper portion of the Lower Patapsco Aquifer is largely based on the data gathered during the step drawdown test conducted on May 5, 2014. Given the drawdown observed during both the step and constant rate tests, a partially penetrating well that is constructed similar to TW-2 should be able to achieve long term sustainable yields approaching 50 gpm. The water level and pumping rate data obtained during the constant rate test were reviewed to support this determination concerning the long term yield for the extraction well. Using these measurements, the specific capacity of TW-2 is 3.3 gpm/ft. Assuming a 50 percent reduction during the first year of pumping, the long term specific capacity for the extraction well would decrease to 1.65 gpm/ft. The installation of the pump above the well screen would provide for a maximum available drawdown in the well of 45 feet. Based on the above, the long term sustainable yield for well TW-2 (74 gpm) is approximately 2x the pumping rate used during the constant discharge rate test.

Transmissivity and Hydraulic Conductivity

Surficial Aquifer

The data collected during the constant discharge rate test were analyzed using HydroSOLV's AQTESOLV® for Windows software program. The time and corrected drawdown for the extraction and observation wells were evaluated using the Cooley and Case solution for transient flow in a leaky confined aquifer overlain by a water table aquitard. The recovery data were analyzed using the Theis recovery method for confined aquifers.

Table 3 summarizes the calculated hydraulic parameters derived from the corrected drawdown and recovery data collected during the constant discharge rate pumping test. Transmissivity values were derived directly from the respective solution method; the corresponding K values were calculated by dividing the T value by the thickness of the sand unit in the area around the respective well. Estimated values for the hydraulic conductivity (K), transmissivity (T), and storativity of the sand deposits comprising the leaky confined unit are consistent with typical published values for this type of aquifer material. (WSP was unable to identify any published report providing information on the hydraulic properties of this hydrogeologic unit in Anne Arundel County, Maryland.) The hydraulic conductivity values for the sandy aquifer materials in the area west of the main manufacturing building ranged from 5.2 feet per day (ft/day) to 11 ft/day, with a geometric mean of 9.21 ft/day.

Lower Patapsco Aquifer

The data collected during the constant discharge rate test on the Lower Patapsco Aquifer were analyzed using HydroSOLV's AQTESOLV® for Windows software program. The time and corrected drawdown for the extraction and observation wells were evaluated using the Hantush solution for transient flow to a partially penetrating well in a leaky confined aquifer. The recovery data were analyzed using the Theis recovery method for confined aquifers.

Table 4 summarizes the calculated hydraulic parameters derived from the corrected drawdown and recovery data collected during the constant discharge rate pumping test. As with the analysis of the data for the Surficial Aquifer test, T values were determined directly from the respective solution equation. The K values were calculated by dividing the respective T value obtained from the selected solution method by the aquifer thickness in the general vicinity of the Kop-Flex site. Based on hydrogeologic information gathered during offsite well installation, the inferred thickness of the Lower Patapsco Aquifer in the site vicinity was estimated to be 80 feet.

Aquifer transmissivities obtained from the data analysis show a limited range of values, with a minimum of 1,170 square feet per day (ft^2/day) for well MW-1D to a maximum of 1,620 ft^2/day for MW-26D. The geometric mean of the transmissivity values obtained from the test is 1,410 ft^2/day. The calculated hydraulic conductivity values for the aquifer materials in the area around TW-2 varied from 14.6 ft/day to 20.3 ft/day, with a geometric mean K of 17.7 ft/day. The estimated geometric mean T and K values for the Lower Patapsco Aquifer are similar with the data cited in other hydrogeologic reports for the Coastal Plain deposits. Transmissivity values determined from well tests in the northwest portion of Anne Arundel County, including the Stevenson Road well southeast of the site, are typically on the order of 2,000 ft^2/day. The hydraulic conductivity and storativity values are also within the range of values typical for the unconsolidated sand deposits of the Lower Patapsco Aquifer.

Groundwater Discharge Sampling

Surficial Aquifer

Groundwater discharge samples were collected from the extraction well at the beginning (TW-1-Q1) and the end (TW-1-Q2) of the constant rate pumping test. The analytical results for these samples are summarized in Table 5. The primary chemicals of concern (COCs) at the Kop-Flex site – 1,1,1-trichloroethane (TCA) and its degradation products [1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), and 1,2-DCA], and 1,4-dioxane – were detected above the method detection limit in each of these samples. In addition, very low levels of chlorinated ethenes were also detected in both discharge samples. The total concentrations of the primary COCs were similar during the 3-day pumping period, with 2,730 micrograms per liter (ug/l) detected in the initial sample and 2,701 ug/l in the sample collected shortly before the end of pumping. The concentration of 1,1-DCE in the well discharge decreased from 870 ug/l to 670 ug/l over the test. Conversely, the concentration of 1,4-dioxane increased from the early to late samples.

Lower Patapsco Aquifer

Samples of the groundwater discharge samples were collected from well TW-2 at the beginning (Effluent 1) and the end (Effluent 2) of the constant rate pumping test. The laboratory analytical results for these samples are summarized in Table 6. The primary chemicals of concern (COCs) at the Kop-Flex site – 1,1,1-trichloroethane (TCA) and its degradation products (1,1-DCE and 1,1-DCA), and 1,4-dioxane – were detected above the method detection limit in each of these samples. In addition, trace levels of chlorinated ethenes (trichloroethene and cis-1,2-dichloroethene) were also detected in both discharge samples. The total concentrations of the primary COCs were similar during the 3-day pumping period, with 833 ug/l detected in the May 6th sample and 904 ug/l in the May 9th sample collected shortly before the termination of pumping. These total VOC levels are 1-2x lower than the concentrations found in monitoring wells MW-17D and MW-24D situated along the center-line of the groundwater plume. The lower concentrations probably reflect the extraction of water from both the impacted zone of the aquifer screened by TW-2 and a portion of the aquifer below this well that does not contain any site-related VOCs. The concentration of 1,1-DCE in the well discharge increased from 310 ug/l to 420 ug/l over the test. Conversely, the concentration of 1,4-dioxane decreased from the early to late samples.

If you have any questions concerning the information presented in the aquifer test summary, please do not hesitate to contact us.

Sincerely yours,

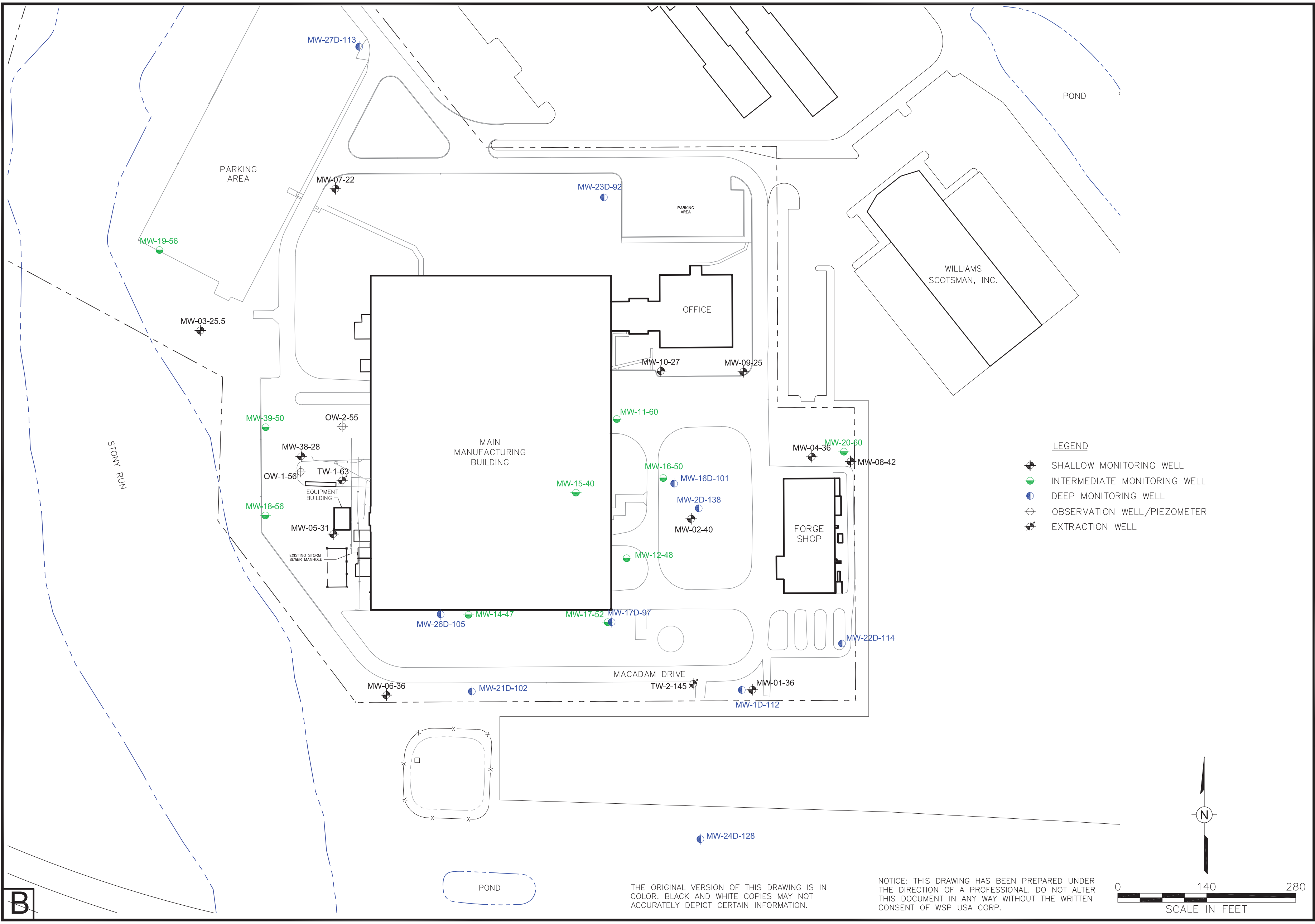
Robert E. Johnson

Eric Johnson
Senior Technical Manager

REJ:jpb:rlo

Enclosure

Figures



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(703) 709-6500
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Figure 1

WELL AND PIEZOMETER LOCATIONS
FOR AQUIFER TESTING ACTIVITIES

KOP-FLEX
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: 6/19/2014
DWG Name: 00003705-157

R:\ACAD\CADD\00003705-Kopflex\CAD\00003705-157.dwg 11/24/2014 3:02 PM USEC01012

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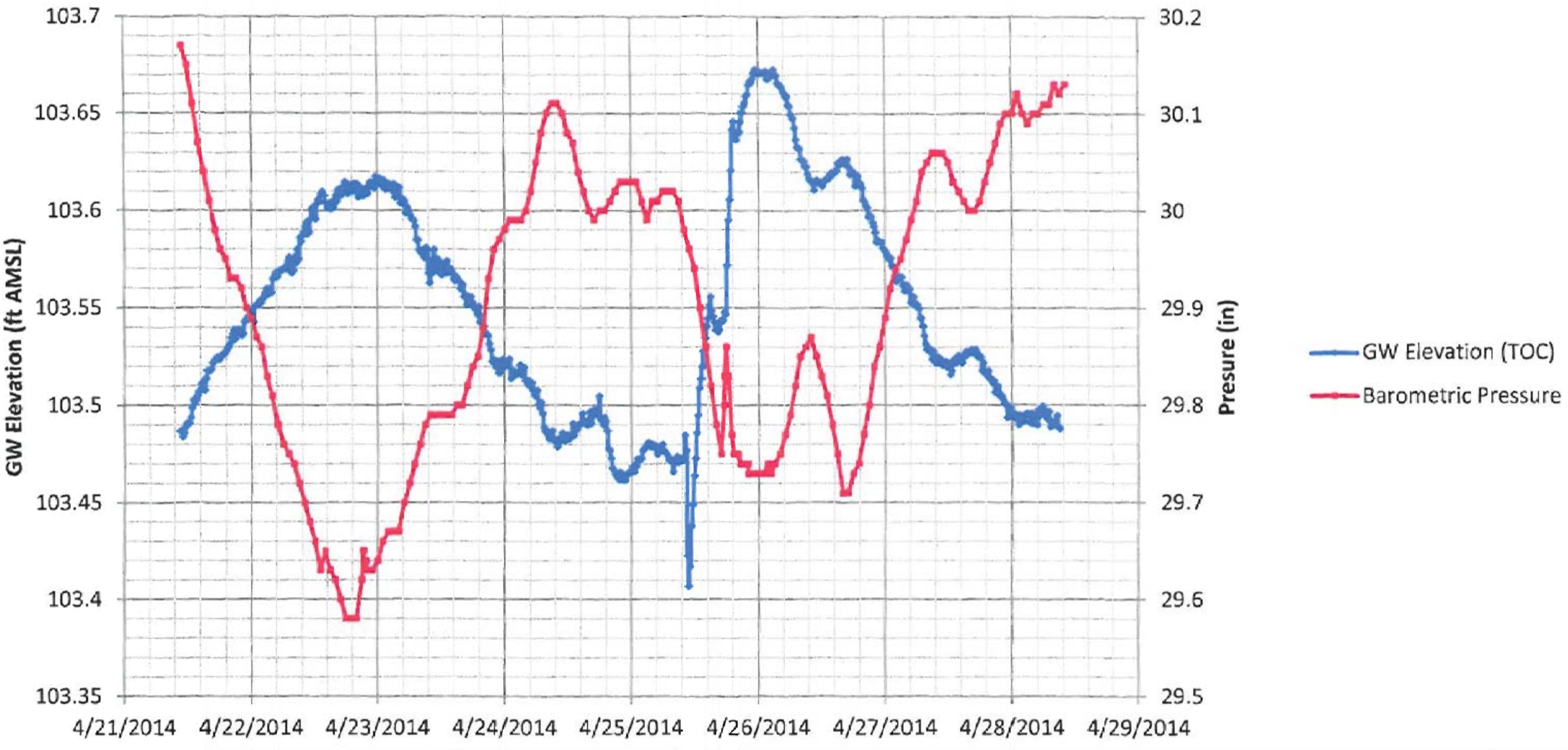

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Figure 2

TIME SERIES ANALYSIS OF WATER LEVEL AND BAROMETRIC PRESSURE FOR WELL MW-39-50, APRIL 21-28, 2014

KOP-FLEX
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: 6/23/2014
DWG Name: 00003705-158

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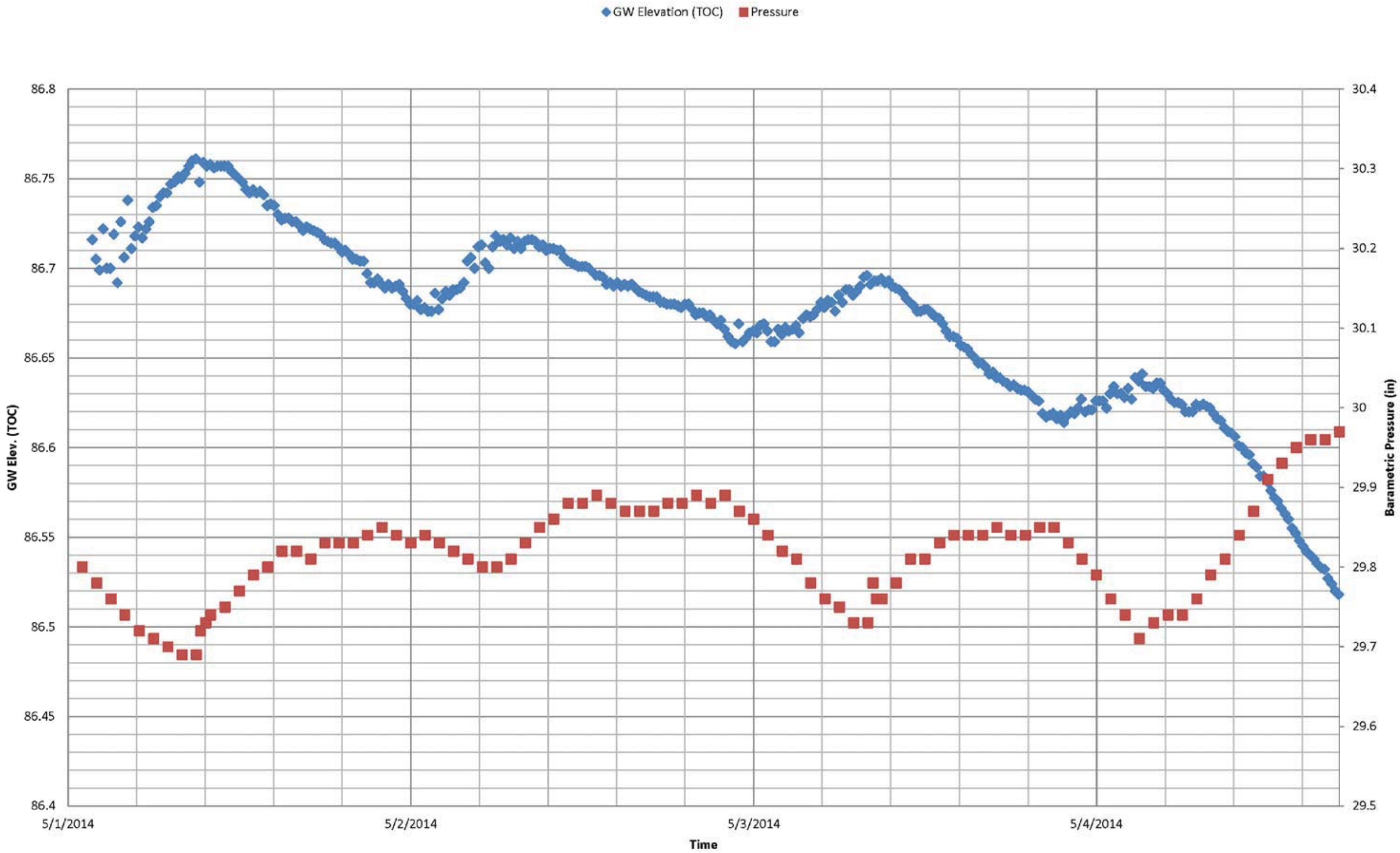

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Figure 3

TIME SERIES ANALYSIS OF WATER LEVEL AND BAROMETRIC PRESSURE FOR WELL MW-17D-97, MAY 1-5, 2014

KOP-FLEX
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: RG 6/23/2014
DWG Name: 00003705-158

R:\ACAD\CADD\00003705-Kopflex\CAD\00003705-158.dwg 6/23/2014 11:52 AM USEC01012

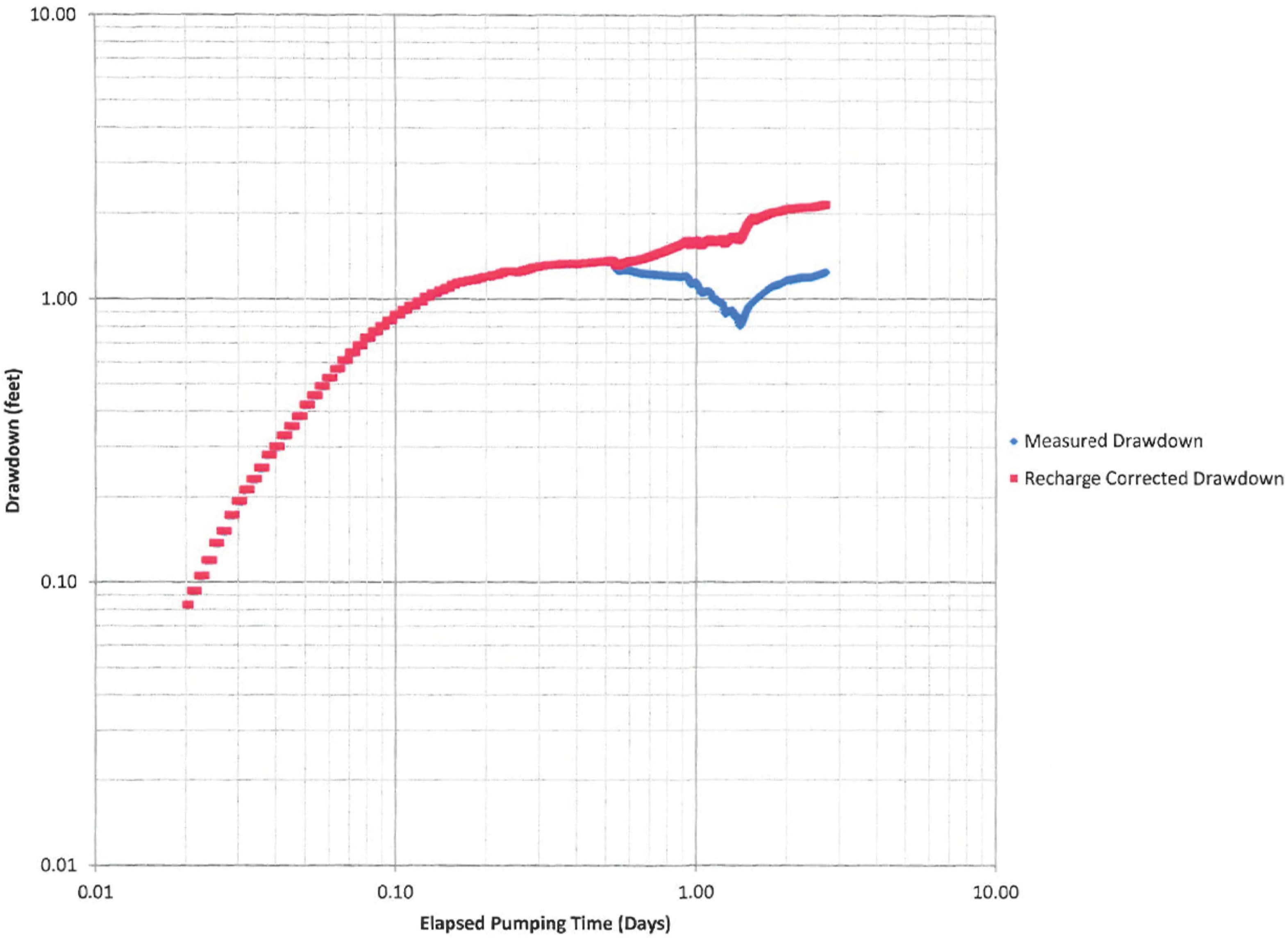

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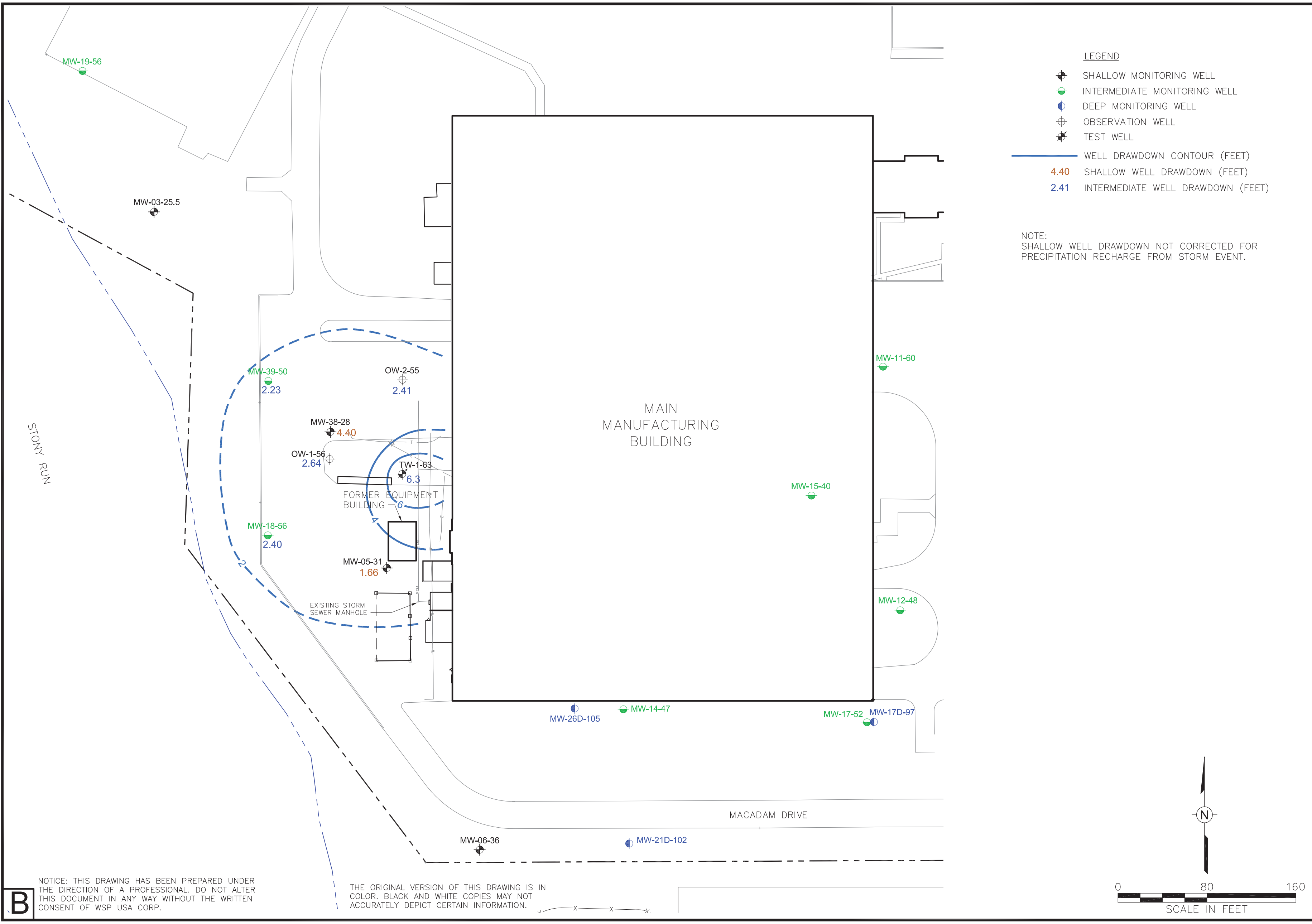
Figure 4

EXAMPLE OF REMOVING PRECIPITATION RECHARGE EFFECT FROM DRAWDOWN DATA, WELL MW−39−50

KOP−FLEX
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: 6/23/2014
DWG Name: 00003705−158



LEGEND

✦	SHALLOW MONITORING WELL
◒	INTERMEDIATE MONITORING WELL
◐	DEEP MONITORING WELL
⌖	OBSERVATION WELL
✦	TEST WELL
─	WELL DRAWDOWN CONTOUR (FEET)
4.40	SHALLOW WELL DRAWDOWN (FEET)
2.41	INTERMEDIATE WELL DRAWDOWN (FEET)

NOTE:
SHALLOW WELL DRAWDOWN NOT CORRECTED FOR PRECIPITATION RECHARGE FROM STORM EVENT.

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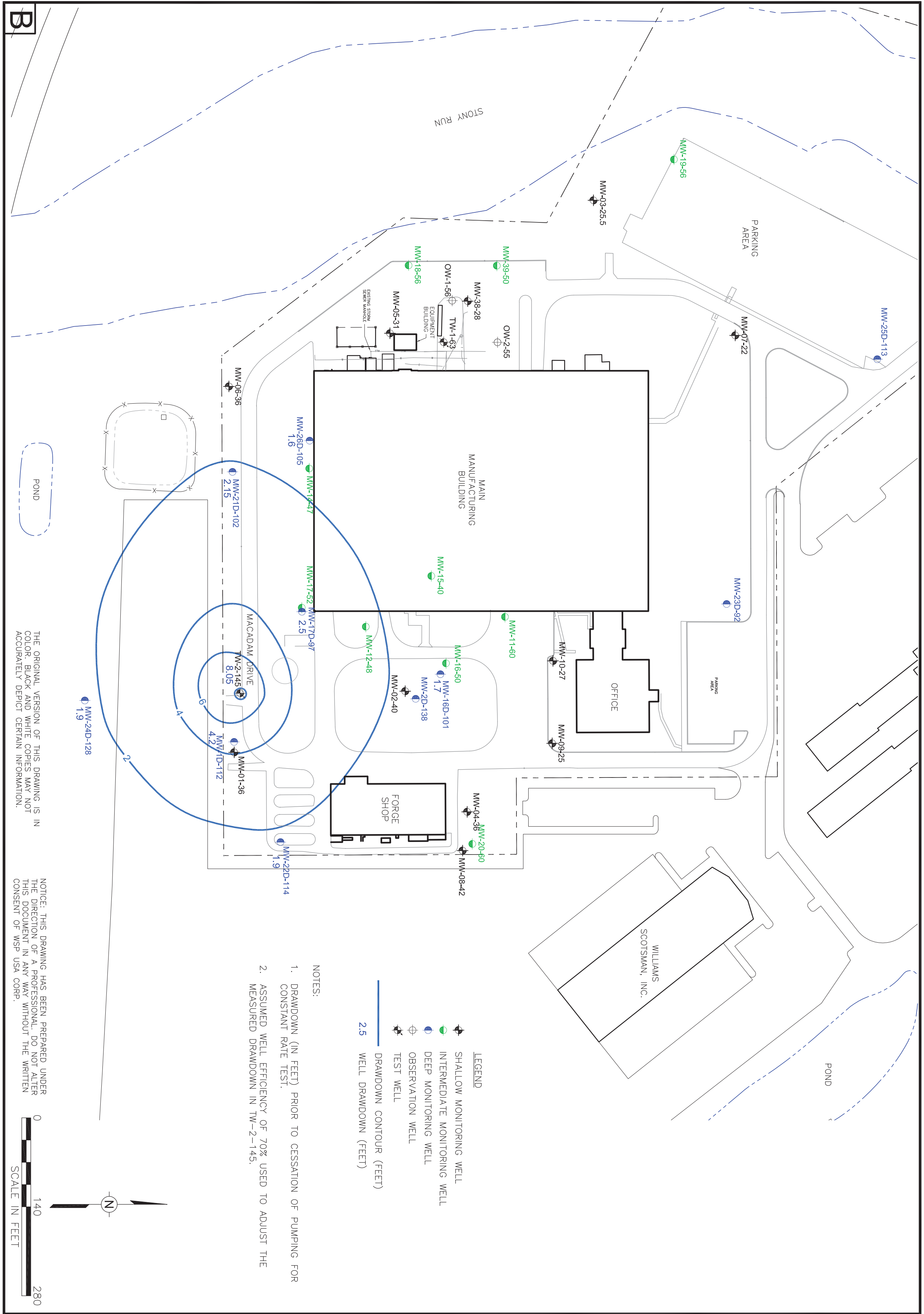
Figure 5

WELL DRAWDOWN AT TERMINATION OF CONSTANT RATE TEST IN THE SURFICIAL AQUIFER

KOP–FLEX
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: 6/9/2014
DWG Name: 00003705–156

R:\ACAD\CADD\00003705-Kopflex\CAD\00003705-156.dwg 11/24/2014 3:05 PM USEC01012



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LEGEND

- ⊕ SHALLOW MONITORING WELL
- ◐ INTERMEDIATE MONITORING WELL
- ◐ DEEP MONITORING WELL
- ⊕ OBSERVATION WELL
- ⊕ TEST WELL
- — DRAWDOWN CONTOUR (FEET)
- 2.5 WELL DRAWDOWN (FEET)

NOTES:

1. DRAWDOWN (IN FEET) PRIOR TO CESSATION OF PUMPING FOR CONSTANT RATE TEST.
2. ASSUMED WELL EFFICIENCY OF 70% USED TO ADJUST THE MEASURED DRAWDOWN IN TW-2-145.

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Figure 6

WELL DRAWDOWN AT TERMINATION OF
CONSTANT RATE TEST IN THE
LOWER PATAPSCO AQUIFER

KOP-FLEX
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By:	EGC
Checked:	
Approved:	RD 5/29/2014
DWG Name:	00003705–155

Tables

Table 1

Well and Piezometer Construction and Water Level Information
Kop-Flex VCP Site
Hanover, Maryland (a)

Well ID	Ground Elevation (feet MSL)	Top of Casin Elevation (feet MSL)	Total Depth (feet bgs)	Screen Interval (feet bgs)	Depth to Water (b) (feet)	Groundwater Elevation (c) (feet MSL)
TW-1	127.08	128.51	63	33 - 63	17.4	111.11
MW-38	123.64	123.40	27	17 - 27	11.94	111.46
MW-39	122.07	121.58	50	40 - 50	16.97	104.61
OW-1	124.39	124.06	56	46 - 56	20.93	103.13
OW-2	123.64	123.23	55	45 - 55	22.15	101.08
TW-2	128.64	129.88	145	100 - 145	45.76	84.12

---

a/ MSL = mean sea level

bgs = below ground surface

b/ Measurements with respect to the top of PVC well casing.

c/ Water level elevations for Surficial Aquifer wells based on April 28, 2014 depth to water measurements.

Water level elevations for well TW-2 in the Lower Patapsco Aquifer based on May 1, 2014 depth to water measurements.

Table 2

Extraction Well TW-2 Depth-Discrete Groundwater Sample Results
Kop-Flex VCP Site
Hanover, Maryland

Analyte (b)	Sample ID	TW-2 111	TW-2 121	TW-2 131	TW-2 141	TW-2 151	TW-2 161	MDE Class I/II Groundwater Quality Standard (µg/l)
	Sample Depth (ft.)	111	121	131	141	151	161	
	Sample Date	4/7/2014	4/8/2014	4/8/2014	4/8/2014	4/8/2014	4/8/2014	
1,1,1-Trichloroethane		54	1 U	8	5.4	1 U	1 U	200
1,1,2-Trichloroethane		1 U	1 U	1 U	1 U	1 U	1 U	5
1,1-Dichloroethane		71	1 U	40	17	1.2	1 U	90
1,1-Dichloroethene		**270**	**10**	**350**	**170**	5.3	1 U	7
1,2-Dichloroethane		3.7	1 U	4	3	1 U	1 U	5
Trichloroethene		1.3	1 U	3.2	1.3	1 U	1 U	5
cis-1,2-Dichloroethene		1 U	1 U	2.3	1	1 U	1 U	70
Total Detected Site VOCs		400	10	408	198	6.5	---	
1,1-Dichloroethene Field Screening Result		12 ppm	0.2 ppm	>14 ppm	8 ppm	0.1-0.2 ppm	<0.1 ppm	

---

a/ U = not detected at a concentration above the method detection limit
Values in bold indicate concentrations above the MDE groundwater standards.
b/ All concentrations in micrograms per liter (µg/l)

Table 3

Aquifer Property Estimates from April-May 2014 Constant Rate Test on the Surficial Aquifer
Kop-Flex VCP Site
Hanover, Maryland

	Hydraulic Conductivity (feet/day) (a)		Transmissivity ($feet^2/day$)		
Well ID	**Drawdown**	**Recovery**	**Drawdown**	**Recovery**	**Storativity**
TW-1	5.2	5.8	146	162	---
MW-18	8.5	10.1	237	282	0.00071
MW-39	8.2	15.6	139	266	0.00082
OW-1	10.6	10.5	298	295	0.00073
OW-2	11	10.8	308	301	0.00087
Geometric Mean	9.21		245		

---

a/ Hydraulic conductivity was calculate by dividing the transmissivity by the thickness of the sand unit. An average sand unit thickness of 28 feet was used for all wells except MW-39, where the thickness value was 17 feet.

Table 4

Aquifer Property Estimates from May 2014 Constant Rate Test on the Lower Patapsco Aquifer
Kop-Flex VCP Site
Hanover, Maryland

	Hydraulic Conductivity (feet/day) (a)		Transmissivity ($feet^2$/day)		
Well ID	**Drawdown**	**Recovery**	**Drawdown**	**Recovery**	**Storativity**
TW-2	16.5	17.8	1,320	1,420	---
MW-1D	14.6	19.0	1,170	1,520	0.000092
MW-17D	17.8	17.5	1,420	1,400	0.00018
MW-21D	18.5	18.1	1,480	1,450	0.00015
MW-22D	17.3	16.3	1,380	1,300	0.00060
MW-24D	18.4	17.3	1,470	1,380	0.00060
MW-16D	19.3	---	1,540	---	0.00015
MW-26D	20.3	---	1,620	---	0.00011
Geometric Mean	17.7		1,410		

---

a/ Hydraulic conductivity was calculate by dividing the transmissivity by the assumed thickness of the Lower Patapsco Aquifer (80 feet).

Table 5

Extraction Well TW-1 Discharge Sample Results
Kop-Flex VCP Site
Hanover, Maryland

Analyte (b)	Sample ID Sample Date	TW-1-Q1 04/29/2014	TW-1-Q2 05/02/2014	MDE Class I/II Groundwater Quality Standard (µg/l)
1,1,1-Trichloroethane		58	51	200
1,1,2-Trichloroethane		5 U	1.6	5
1,1-Dichloroethane		180	170	90
1,1-Dichloroethene		870	670	7
1,2-Dichloroethane		9.1	4.7	5
Trichloroethene		13	6.2	5
cis-1,2-Dichloroethene		5 U	2.4	70
1,4-Dioxane (P-Dioxane)		1,600	1,800	NE
Total Detected VOCs		2,730	2,701	---

---

a/ U = not detected at a concentration above the method detection limit
NE = no standard established by MDE at this time
b/ All concentrations in micrograms per liter (µg/l)

Table 6

Extraction Well TW-2 Discharge Sample Results
Kop-Flex VCP Site
Hanover, Maryland

Analyte (b)	Sample ID Sample Date	TW-2 Effluent 1 5/6/2014	TW-2 Effluent 2 5/9/2014	MDE Class I/II Groundwater Quality Standard (µg/l)
1,1,1-Trichloroethane		71	53	200
1,1,2-Trichloroethane		1.3	1.1	5
1,1-Dichloroethane		82	68	90
1,1-Dichloroethene		310	420	7
1,2-Dichloroethane		6.6	6.5	5
Trichloroethene		1.9	3.8	5
cis-1,2-Dichloroethene		1 U	1.6	70
1,4-Dioxane (P-Dioxane)		410	360	NE
Total Detected VOCs		883	914	---

---

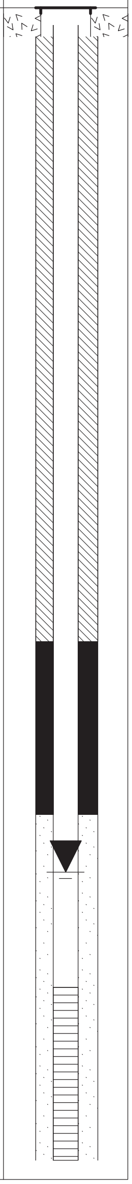
a/ U = not detected at a concentration above the method detection limit
NE = no standard established by MDE at this time
b/ All concentrations in micrograms per liter (µg/l)

Enclosure A – Boring and Well Completion Logs for Newly Installed Wells and Piezometers

Boring Log: MW-38

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 36
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
						Ground Surface	
2							
4							
6							
						Refer to Boring Log for OW-1 for soil descriptions.	
8							
10							
			-	100			
12							
14							
16							
18							
20							

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

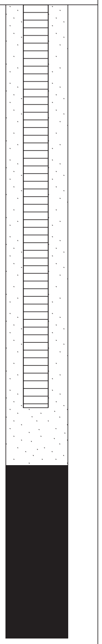
WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: MW-38

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 36
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
22 24			-	100		Refer to Boring Log for OW-1 for soil descriptions. *(continued)*	
26 28 30			-	100			
32 34							
36 38 40						Bottom of Boring at 36 feet	



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: MW-39

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 56
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data

Depth	Sample/Interval	PID/OVM (ppm)	Blow Count	% Recovery
0–6			-	100
6–16			-	100
16–20				

Subsurface Profile

Description

Ground Surface

Poorly-Graded Sand (SP)
Fill: Strong brown (7.5 YR 6/8) coarse sand with some gravel. Loose, moist.

Well-Graded Sand (SW)
Reddish yellow (7.5 YR 6/6) fine to medium sand. Loose, moist.

Clayey Sand with Gravel (SC)
Dark gray (10 YR 4/1) clayey sand with some gravel. Coarse sand. Moist, dense.

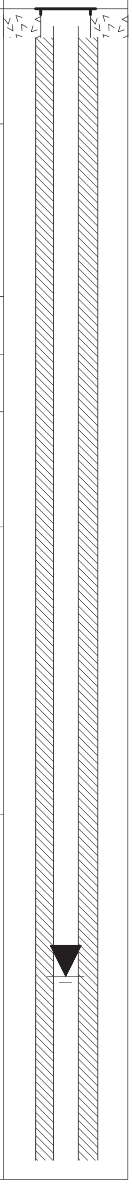
Poorly-Graded Sand (SP)
Reddish yellow (7.5 YR 6/8) medium sand, loose, moist. Trace coarse gravel.

Clayey Sand with Gravel (SC)
Mottled white (5 YR 8/1) and light red (2.5 YR 6/8) reddish yellow (7.5 YR 5/8) clayey medium sand with some gravel. Medium dense.

Lean Clay (CL)
White (5YR 8/1) mottled red (2.5 YR 4/8) and reddish yellow (7.5 yr 6/8) silty clay. Hard, dense, dry.

Lean Clay (CL)
Dark gray (10 YR 4/1) clay. Very dense, hard, dry. Trace silt. Medium soft to stiff.

Well Details



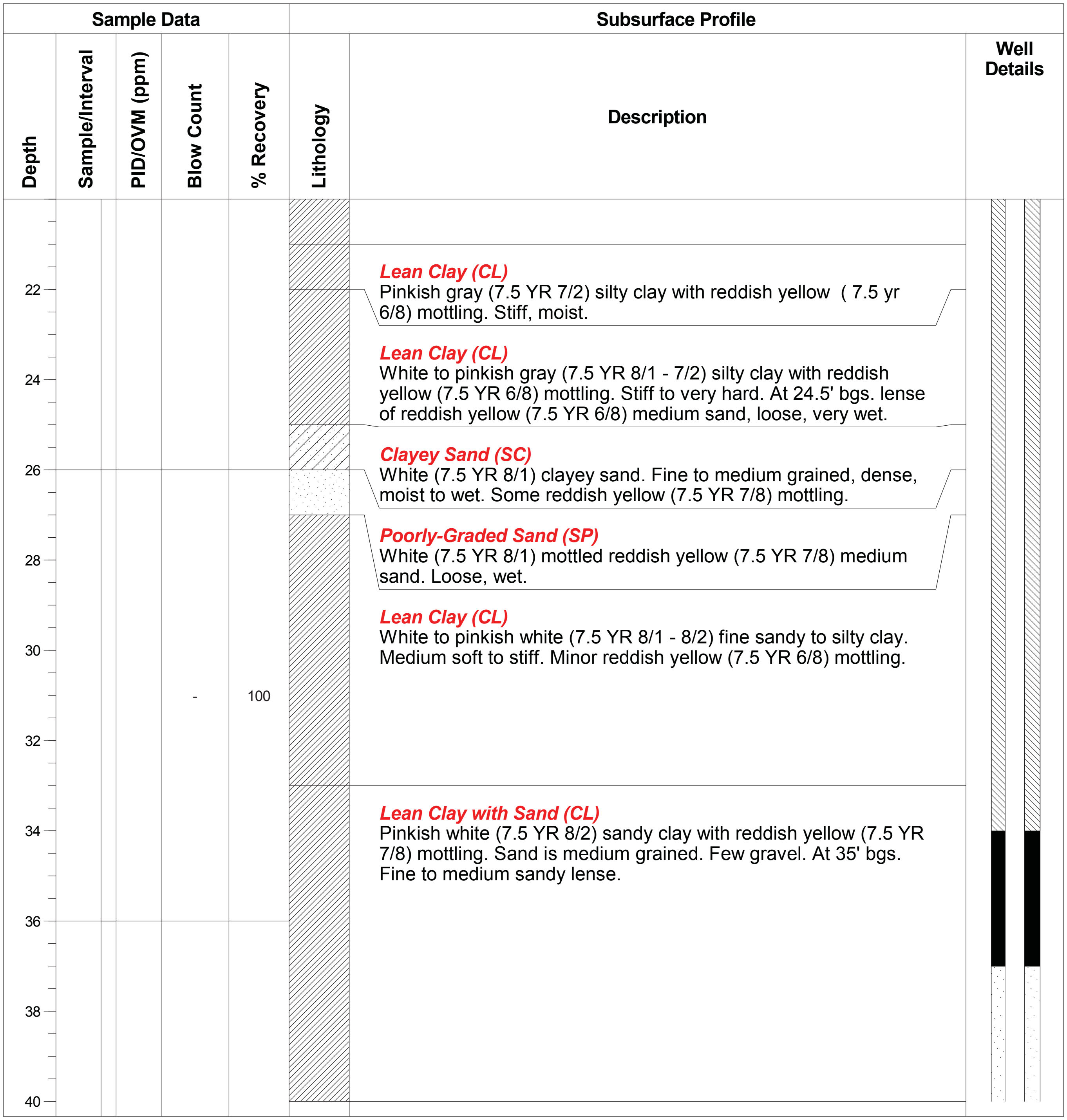
Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: MW-39

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 56
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*



Lean Clay (CL)
Pinkish gray (7.5 YR 7/2) silty clay with reddish yellow (7.5 yr 6/8) mottling. Stiff, moist.

Lean Clay (CL)
White to pinkish gray (7.5 YR 8/1 - 7/2) silty clay with reddish yellow (7.5 YR 6/8) mottling. Stiff to very hard. At 24.5' bgs. lense of reddish yellow (7.5 YR 6/8) medium sand, loose, very wet.

Clayey Sand (SC)
White (7.5 YR 8/1) clayey sand. Fine to medium grained, dense, moist to wet. Some reddish yellow (7.5 YR 7/8) mottling.

Poorly-Graded Sand (SP)
White (7.5 YR 8/1) mottled reddish yellow (7.5 YR 7/8) medium sand. Loose, wet.

Lean Clay (CL)
White to pinkish white (7.5 YR 8/1 - 8/2) fine sandy to silty clay. Medium soft to stiff. Minor reddish yellow (7.5 YR 6/8) mottling.

Lean Clay with Sand (CL)
Pinkish white (7.5 YR 8/2) sandy clay with reddish yellow (7.5 YR 7/8) mottling. Sand is medium grained. Few gravel. At 35' bgs. Fine to medium sandy lense.

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: MW-39

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined

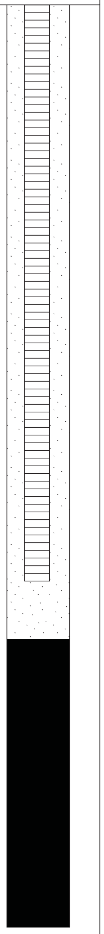
TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 56

Borehole Diameter (inches): 7

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
42 44			-	100	▨	***Lean Clay (CL)*** White (7.5 YR 8/1) mottled reddish yellow (7.5 YR 7/8) silty clay. Stiff, dry. Soft/wet area at 41' bgs.	
46 48					░	***Well-Graded Sand (SW)*** White to pinkish white (7.5 YR 8/1 - 8/2)silty fine to medium sand. Loose, moist to wet.	
50 52 54			-	100	▨	***Lean Clay (CL)*** White (7.5 YR 8/1) mottled reddish yellow (7.5 YR 6/8) (minor) silty clay. Mostly hard with medium soft to stiff areas. Very dry.	
56 58 60						Bottom of Boring at 56 feet	



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: OW-1

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined

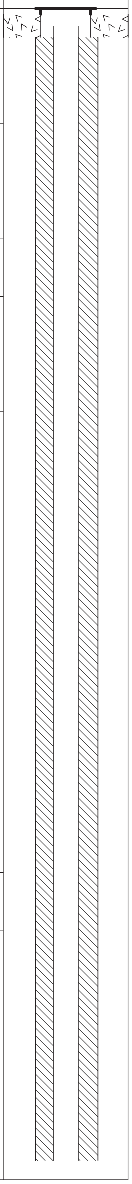
TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 56

Borehole Diameter (inches): 7

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description** Ground Surface	**Well Details**
					░	***Poorly-Graded Sand with Gravel (SP)*** Fill: Light brown (7.5 YR 6/3) coarse to medium sand and coarse gravel. Moist, loose.	
2			-	100	▨	***Lean Clay (CL)*** Very pale brown to white (10 YR 7/3 - 8/1) mottled reddish yellow (7.5 YR 5/8) silty clay. Dry, stiff.	
4					▨	***Lean Clay with Sand (CL)*** Yellowish red to red (5 YR 5/8) to (2.5 YR 4/8) ***Lean Clay (CL)*** White to pinkish white (7.5 YR 8/1 to 8/2) mottled reddish yellow (7.5 YR 6/8) silty clay. Dry, stiff.	
6					▨		
8					▨	***Lean Clay (CL)*** Red (10 R 4/6) white (10 R 8/1) and strong brown (7.5 YR 5/6) mottled clay with silt. Very stiff to hard, dry.	
10			-	100	▨		
12					▨		
14					▨		
16					▨	***Lean Clay (CL)*** Light gray (7.5 yr 7/1) clay with dark red (2.5 yr 3/6) mottling. Very stiff, dry.	
18					▨	***Lean Clay (CL)*** Dark gray to very dark gray (7.5 YR 4/1 - 3/1) Silty clay. Stiff, dry. Fine sand lense at 20' and 21' bgs.	
20							



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

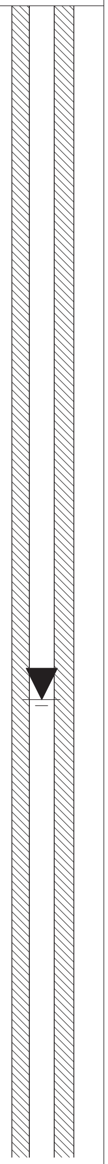
Boring Log: OW-1

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 56
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile	
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**
20–22			-	100	▨	***Lean Clay (CL)*** Dark gray to very dark gray (7.5 YR 4/1 - 3/1) Silty clay. Stiff, dry. Fine sand lense at 20' and 21' bgs. *(continued)*
22–26					▨	***Lean Clay (CL)*** Pink (7.5 YR 3/6) and reddish yellow (7/5 YR 6/8) mottled silty clay. Trace sand. Hard, dry.
26–27					▨	***Lean Clay (CL)*** Dark red (2.5 YR 3/6) clay with some silt. Medium soft, moist.
27–30					▨	***Lean Clay (CL)*** White (7.5 YR 8/1) and dark red (2.5 YR 3/6) mottled clay with some silt. medium soft, moist.
30–38			-	100	░	***Well-Graded Sand (SW)*** Pink (7.5 YR 8/1) medium to fine sand. Loose, moist. Some reddish yellow (7.5 YR 7/8) mottling. Some clay towards 30'-31'.
38–40					▨ ░	***Lean Clay with Sand (CL)*** White (7.5 YR 8/3) mottled reddish yellow (7.5 YR 6/8) sandy clay. Fine sand. Medium soft.

Well Details



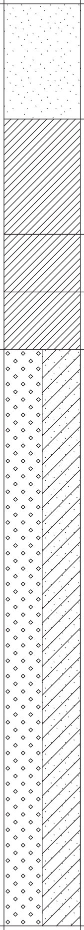
Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

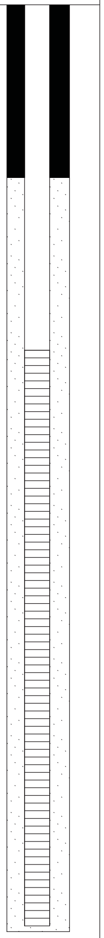
WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: OW-1

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 4, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 56
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*





Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
			-	100		***Poorly-Graded Sand (SP)*** White to pinkish white (7.5 YR 8/1 - 8/2) medium to coarse sand. Wet, loose. Some reddish yellow (7.5 YR 7/8) mottling. *(continued)*	
42						***Lean Clay with Sand (CL)*** White (7.5 YR 8/1) and reddish yellow (7.4 YR 7/8) mottled fine sandy clay . Medium soft, moist.	
44						***Lean Clay (CL)*** White (7.5 YR 8/1) and reddish yellow (7.4 YR 7/8) mottled silty clay. Stiff to very stiff. Dry to moist.	
46						***Lean Clay with Sand (CL)*** Pinkish white (7.5 YR 8/2) sandy clay with coarse gravel. Stiff to medium soft, moist.	
48 50 52 54			-	100		***Well-Graded Sand with Clay (SW-SC)*** White to pinkish white (7.5 YR 8/1-8/2) clayey fine to medium sand. Minor reddish yellow (7.5 YR 7/8) mottling. Wet, loose.	
56						Bottom of Boring at 56 feet	
58							
60							

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

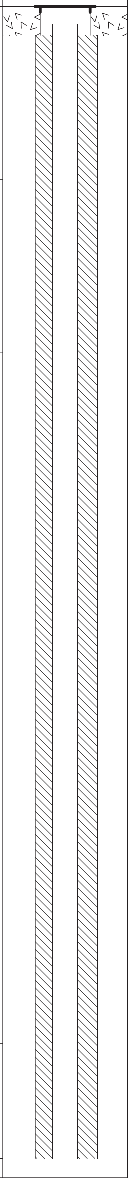
Boring Log:* *OW-2

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 3, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 66
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile	
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description** Ground Surface
2			-	100	░	***Poorly-Graded Sand (SP)*** 4" concrete slab. Fill material: Strong brown to reddish yellow (7.5 YR 6/8 - 5/8) very coarse sand with some coarse gravel. Moist, medium dense.
4 6					▨	***Lean Clay (CL)*** Pinkish white (7.5 YR 8/2) silty clay mottled with reddish yellow (7.5 YR 6/8) silty clay. Hard, moist. Trace gravel.
8 10 12 14 16 18			-	100	▨	***Lean Clay (CL)*** Dark red (2.5 YR 3/6) clay. Stiff, dry. Thine white (10 R 8/1) lense at 11.5' bgs.
20					▨	***Lean Clay (CL)*** White (10 R 8/1) clay. Dry, stiff, trace silt.

Well Details



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Sample Data

Depth	Sample/Interval	PID/OVM (ppm)	Blow Count	% Recovery
20–26			-	100
26–36			-	100
36–40				

Subsurface Profile

Description

Lean Clay (CL)
Dark gray (7.5 YR 8/1) clay. Stiff, dry. Strong brown (7.5 YR 5/8) mottling at 22'-23' bgs.

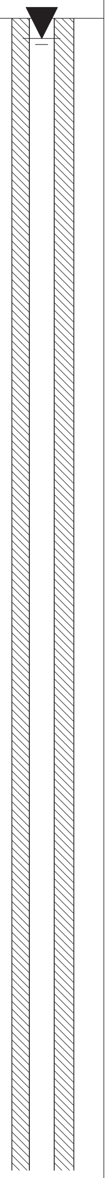
Lean Clay (CL)
Pinkish gray (7.5 YR 6/2) to pinkish white (7.5 YR 8/2) clay with some reddish yellow mottling (7.5 YR 6/8). Dense, stiff, dry.

Lean Clay (CL)
White (10 R 8/1) mottled reddish yellow (7.5 YR 6/8) silty clay. Dense, very stiff, dry.

Lean Clay (CL)
White (10 R 8/1) and Red (10 R 4/8) mottled silty clay. Very stiff, dry. "Marbled" appearance.

Poorly-Graded Sand (SP)
Brownish yellow (10 YR 6/6) grading to pink (7.5 YR 8/3) medium sand. Loose, wet.

Well Details



Boring Log: OW-2

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 3, 2014

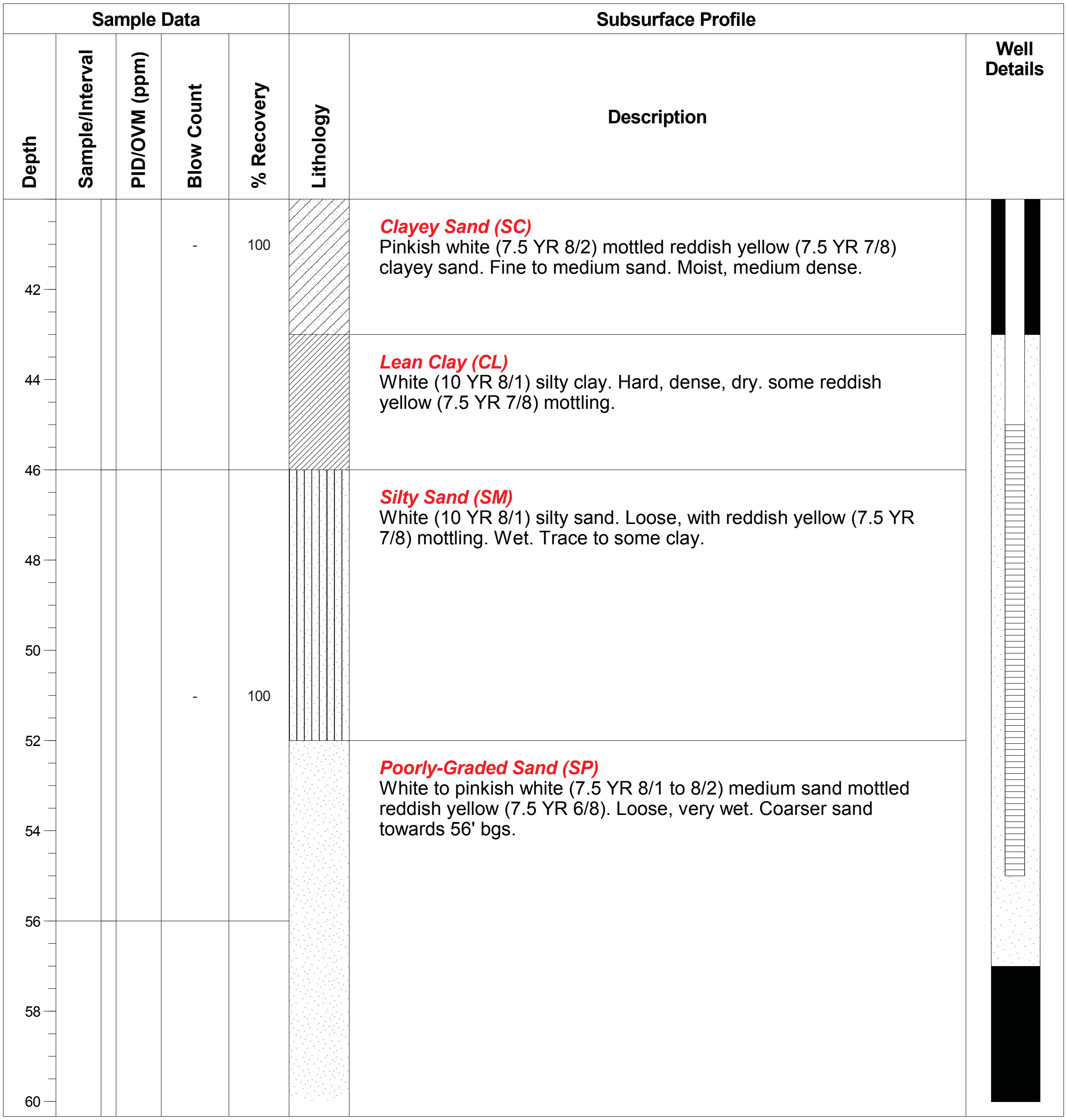
Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 66

Borehole Diameter (inches): 7

**AMSL = Above mean sea level*



Clayey Sand (SC)
Pinkish white (7.5 YR 8/2) mottled reddish yellow (7.5 YR 7/8) clayey sand. Fine to medium sand. Moist, medium dense.

Lean Clay (CL)
White (10 YR 8/1) silty clay. Hard, dense, dry. some reddish yellow (7.5 YR 7/8) mottling.

Silty Sand (SM)
White (10 YR 8/1) silty sand. Loose, with reddish yellow (7.5 YR 7/8) mottling. Wet. Trace to some clay.

Poorly-Graded Sand (SP)
White to pinkish white (7.5 YR 8/1 to 8/2) medium sand mottled reddish yellow (7.5 YR 6/8). Loose, very wet. Coarser sand towards 56' bgs.

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: OW-2

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 3, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 66
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
			-	100	░		■
62					▨	***Lean Clay (CL)*** Pinkish white (7.5 YR 8/1) mottled reddish yellow (7.5 YR 6/8) silty clay. Hard, dry.	■
64					▨		■
					▨	***Clayey Sand (SC)*** Pinkish white (7.5 YR 8/1) clayey sand. Sand is fine to medium. Wet, loose.	■
66						Bottom of Boring at 66 feet	
68							
70							
72							
74							
76							
78							
80							

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log:* *TW-2

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

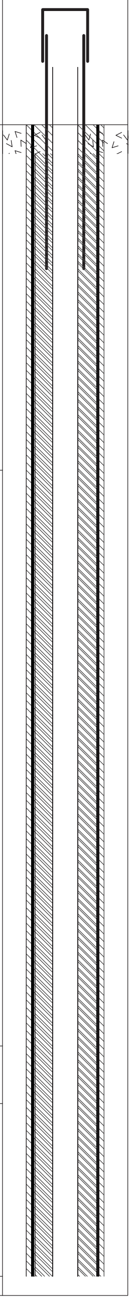
Total Depth (feet): 156

Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile	
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description** Ground Surface
2 4			-	100		***Poorly-Graded Sand (SP)*** Brownish yellow (10 YR 6/6) fine to medium sand. Loose, moist.
6 8 10 12 14			-	100		***Well-Graded Sand (SW)*** Pink (7.5 YR 8/3) fine to medium sand. with minor reddish yellow (7.5 YR 7/8) mottling. Loose, moist.
16 18 20						***Well-Graded Sand (SW)*** Dark Brown (7.5 YR 3/3) fine to medium sand. Loose, moist ***Poorly-Graded Sand (SP)*** Reddish yellow (7.5 YR 7/8) clayey medium to coarse sand with coarse gravel. Very moist to wet. Medium dense sand.

Well Details



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log:* *TW-2

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 156
Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
22 24			-	100		***Fat Clay (CH)*** White to pinkish white (7/5 YR 8/1 - 8/2) mottled reddish yellow (7.5 YR 7/8) clay. Moist, soft to medium soft.	
26						***Well-Graded Sand with Clay (SW-SC)*** Pink (7.5 YR 8/3) fine to medium clayey sand. Loose, moist, some clay clumps.	
28						***Lean Clay (CL)*** Light gray (7.5 YR 7/1) clay. Hard, dry.	
30 32 34 36			-	100		***Lean Clay (CL)*** Dusky red to dark red (5 R 3/4 - 3/6) silty clay. Dry to moist. Medium soft to stiff. Minor white (7.5 YR 8/1) mottling.	
38 40						***Lean Clay with Sand (CL)*** White to light gray (7.5 YR 8/1 - 7/1) silty to fine sandy clay. Very stiff to hard. Dry.	

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

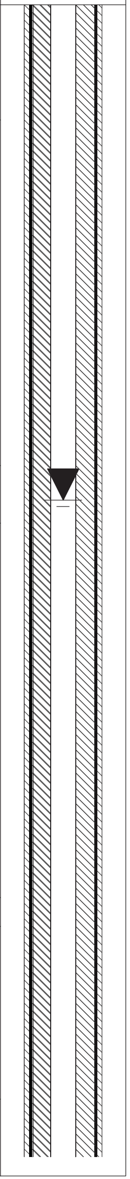
Boring Log: TW-2

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 156
Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile	
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**
			-	100	▨	***Lean Clay with Sand (CL)*** White to light gray (7.5 YR 8/1 - 7/1) silty to fine sandy clay. Very stiff to hard. Dry. *(continued)*
42					▨	***Lean Clay (CL)*** Dark gray to very dark gray (7.5 YR 4/1 -3/1) mottled light gray (7.5 YR 7/1) silty clay. Lense of fine sandy clay at 44'-45' bgs. Sand is light gray (7.5 YR 7/1).
44						
46						
48					▨	***Lean Clay with Sand (CL)*** Very pale brown (10 R 8/3) to yellow (10 R 7/8) fine sandy clay. Very stiff, dry.
50			-	100	▨	***Lean Clay (CL)*** Pinkish white to pinkish gray (7.5 YR 8/2 - 7/2) silty clay. Minor reddish yellow (7.5 YR 7/8) mottling. Very thin fine reddish yellow sandy lense (7.5 YR 7/8) at 50' bgs. 6" clayey sand lense at 51' bgs.
52						
54						
56					▨	***Lean Clay (CL)*** Dark Red (5 R 3/6) and white (7.5 YR 8/1) mottled clay with some silt. Stiff to hard, dry.
58					▨	***Lean Clay (CL)*** Red (5 R 4/8) mottled very dusky red (5 R 2.5/4) and white (5 R 8/1) clay. Very stiff to hard, dry, some silt.
60						

Well Details



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log:* *TW-2

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 156
Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
62			-	100	▨	***Lean Clay (CL)*** Dark Red (7.5 R 3/6) mottled white (7.5 YR 8/1) silty clay with medium sand. Hard, dry. *(continued)*	
64 66 68					▨	***Lean Clay (CL)*** Red (10 R 4/6) clay. Very hard, dry. Some silt.	
70 72 74			-	100	▨	***Lean Clay (CL)*** Red (10 R 4/6) mottled strong brown (7.5 YR 4/6) and minor white to light gray (7.5 YR 8/1 - 7/1) clay with some to few silt. Stiff to very stiff, dry.	
76 78					▨	***Lean Clay (CL)*** Dark gray (7.5 YR 4/1) silty clay with thin laminae of light gray (7.5 YR 7/1) fine sand. Very stiff, dry.	
80					▨		

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-2

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 156

Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
80–86			-	100	▨	***Lean Clay with Sand (CL)*** Dark gray (7.5 YR 4/1) silty clay with some sand. Minor red (2.5 YR 5/6) coloration. Very stiff to hard. Carbonized plant matter present. Softer towards 86' bgs. Light gray (7.5 YR 7/1) fine sand laminations. *(continued)*	▨
86–90					▨		▨
90–93			-	100	▨	***Lean Clay with Sand (CL)*** Pinkish gray to pink (7.5 YR 7/2 - 7/3) silty clay with fine sand. Mottled. Carbonized plant matter present.	▨
93–94					▨	***Lean Clay (CL)*** Red (10 R 4/6) clay mottled white (10 R 8/1) and reddish yellow (7.5 YR 7/8). Some silt, hard, dry.	▨
94–95					▨		■
95–96					░	***Poorly-Graded Sand with Gravel (SP)*** Brown (7.5 YR 4/4) coarse to medium sand with coarse gravel. (quartz gravel) Loose, wet.	■
96–97					░		■
97–100					░	***Poorly-Graded Sand with Gravel (SP)*** Pink (7.5 YR 7/3) coarse sand with gravel. Very coarse quartz gravel. Loose, wet.	░

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log:* *TW-2

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 156

Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	Sample/Interval	PID/OVM (ppm)	Blow Count	% Recovery	Lithology	Description	Well Details
			-	100		***Poorly-Graded Gravel (GP)*** Coarse quartz gravel and pebbles with some white (7.5 YR 8/1) clay and pink coarse sand (7.5 YR 8/3). Loose, wet. Some white clay clumps.	
102							
104							
106							
108							
110							
	TW-2 111'		-	100		***Lean Clay (CL)*** White (7.5 YR 8/1) silty clay minor reddish yellow (7.5 YR 7/8) mottling. Stiff, dry.	
112							
						Well-Graded Sand (SW) Pink to pinkish white (5 YR 8/3) to 8/2) fine to medium sand with some silt. Loose to medium dense, wet. 4" white clay lense at 115' bgs. Some reddish yellow (7.5 YR 7/8) mottling in sand.	
114							
116							
118							
120							

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-2

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 8, 2014

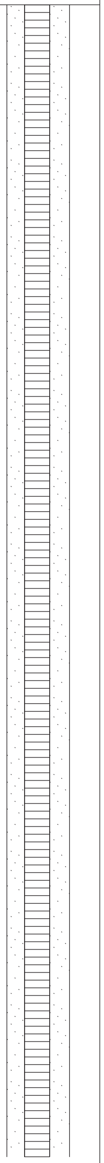
Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 156

Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')

**AMSL = Above mean sea level*

Sample Data					**Subsurface Profile**		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
122 124	TW-2 121'		-	100		***Poorly-Graded Sand (SP)*** Light reddish brown to pink (2.5 YR 7/3 - 7/4) with minor reddish brown (7.5 YR 7/8) mottling, medium sand. Loose, wet. Some white (7.5 YR 8/1) and yellowish brown (7.5 YR 7/8) mottled clay clumps. *(continued)*	
126 128 130 132 134	TW-2 131'		-	100			
136 138 140						***Poorly-Graded Sand (SP)*** Pink to reddish yellow (7.5 YR 8/3 - 7/6) medium to coarse sand with some gravel. White clay clumps. Loose, wet. Minor reddish yellow (7.5 YR 7/8) mottling of the sand. Gravel is coarse gravel to cobble.	

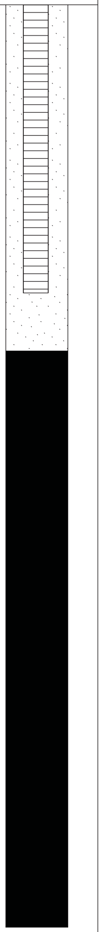
Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-2

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 8, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 156
Borehole Diameter (inches): 12 (0'-61.5') 7 (61.5'- 156')
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
142 144	TW-2 141'		-	100		***Poorly-Graded Sand (SP)*** Pink to reddish yellow (7.5 YR 8/3 - 7/6) medium to coarse sand with some gravel. White clay clumps. Loose, wet. Minor reddish yellow (7.5 YR 7/8) mottling of the sand. Gravel is coarse gravel to cobble. *(continued)*	
146 148 150 152 154	TW-2 151'		-	100			
156 158 160	<-- TW-2 161'		-			Bottom of Boring at 156 feet	

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-I

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 2, 2014

Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

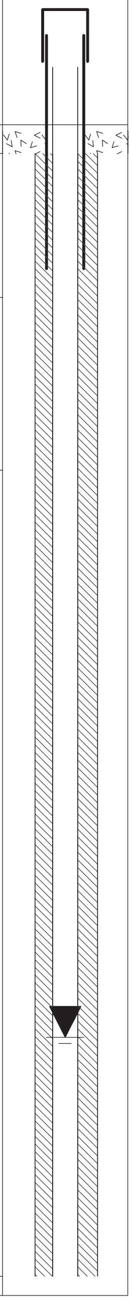
Total Depth (feet): 66

Borehole Diameter (inches): 7

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile	
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**
0						Ground Surface
0–0.5			-	100		***Organic Soil (OL/OH)*** Grass and moist top soil.
0.5–3						***Poorly-Graded Sand (SP)*** Reddish Yellow (7.5 YR 6/8) medium to coarse sand. Fill material. Sandy clay lense at 1.5' bgs.
3–6						***Clayey Sand with Gravel (SC)*** Pink (5 yr 7/4) clayey sand with gravel, few cobbles. Very coarse sand toward 6' bgs. Moist.
6–16			-	100		***Lean Clay (CL)*** Red (2.5 Yr 5/6 to 5/8) silty clay with trace sand. Very stiff. Hard and dry at 16' bgs. White (2.5 YR 8/1) sandy clay lenses at 8' bgs and 13' bgs.
16–20						

Well Details



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

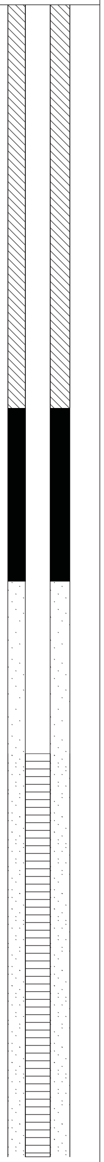
WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-I

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 2, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 66
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
22 24			-	100	▨	***Lean Clay (CL)*** Light Gray (2.5 y 7/1) silty clay grading to dark gray (2.5 Y 5/1). Very hard to stiff, dry. Light gray (2.5 Y 7/1) silty fine sand at 26' bgs.	
26 28 30			-	100	▨	***Lean Clay (CL)*** Dark Gray (5 YR 4/1) silty clay. Very stiff to hard, dry.	
32					░	***Poorly-Graded Sand (SP)*** Reddish yellow (7.5 YR 6/6) coarse to medium sand mottled dark red (10 R 3/6).	
34 36 38 40					░	***Well-Graded Sand (SW)*** Pink (10 R 8/3) fine to medium sand, moist.	



Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-I

Project: Kop-Flex

Project No.: 3705

Location: Hanover, MD

Completion Date: April 2, 2014

Surface Elevation (feet AMSL*): Not Determined

TOC Elevation (feet AMSL*): Not Determined

Total Depth (feet): 66

Borehole Diameter (inches): 7

**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	Sample/Interval	PID/OVM (ppm)	Blow Count	% Recovery	Lithology	Description	Well Details
42 44 46			-	100		***Poorly-Graded Sand (SP)*** Yellowish Red (5 YR 5/6) medium to coarse sand. Moist, loose. Grades to pinkish white (5 YR 8/2) at 43' bgs. White (5 YR 8/1) silty clay lense at 45' bgs.	
48 50 52 54 56			-	100		***Poorly-Graded Sand (SP)*** Reddish yellow (7.5 YR 6/6) medium to coarse sand. Loose, wet. 8" white (7/5 YR 8/1) silty clay lense at 47' bgs.	
58 60						***Poorly-Graded Sand (SP)*** White (7.5 YR 8/1) medium sand with some reddish yellow (7.5 YR 6/8) mottling. Loose, wet, few to some coarse gravel.	

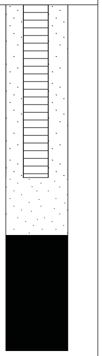
Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Boring Log: TW-I

Project: Kop-Flex
Project No.: 3705
Location: Hanover, MD
Completion Date: April 2, 2014

Surface Elevation (feet AMSL*): Not Determined
TOC Elevation (feet AMSL*): Not Determined
Total Depth (feet): 66
Borehole Diameter (inches): 7
**AMSL = Above mean sea level*

Sample Data					Subsurface Profile		
Depth	**Sample/Interval**	**PID/OVM (ppm)**	**Blow Count**	**% Recovery**	**Lithology**	**Description**	**Well Details**
62			-	100	░	***Poorly-Graded Sand (SP)*** White (7.5 YR 8/1) medium sand with some reddish yellow (7.5 YR 6/8) mottling. Loose, wet, few to some coarse gravel. *(continued)*	
64					▨	***Lean Clay (CL)*** White (7.5 YR 8/1) silty clay with reddish yellow (7.5 YR 6/8) mottling. Stiff, dry. Silty clay lense at 63' bgs.	
66 68 70 72 74 76 78 80						Bottom of Boring at 66 feet	

Geologist(s): Paul Zarella
Subcontractor: Cascade
Driller/Operator: Josh Siegler
Method: Rotosonic

WSP
1740 Massachusetts Ave
Boxborough, MA 01719
1-978-635-9600

Appendix E – Soil Management Plan

Department of the Environment

Facts About...

VCP - Clean Imported Fill Material

The purpose of the Voluntary Cleanup Program (VCP) is to encourage the cleanup and redevelopment of properties throughout Maryland. In many cases, fill materials are imported onto a property as part of the redevelopment process. As more properties are relying upon the use of imported fill materials, the VCP has prepared this guidance document for assisting participants who anticipate using imported fill material at VCP sites.

Introduction

No one wants to introduce new contamination onto a VCP site through the importation of fill material that is believed to be clean. This document was developed specifically for VCP participants who seek guidance on steps to take to minimize the possibility of importing contaminated fill onto VCP sites.

Overview

Because fill material may come from a variety of sources, it is important to determine that any material brought onto a VCP site not only meets engineering specifications for a particular use, but that it also passes some level of screening to ensure that it is, in fact, clean.

Residential or Commercial/ Industrial Scenario

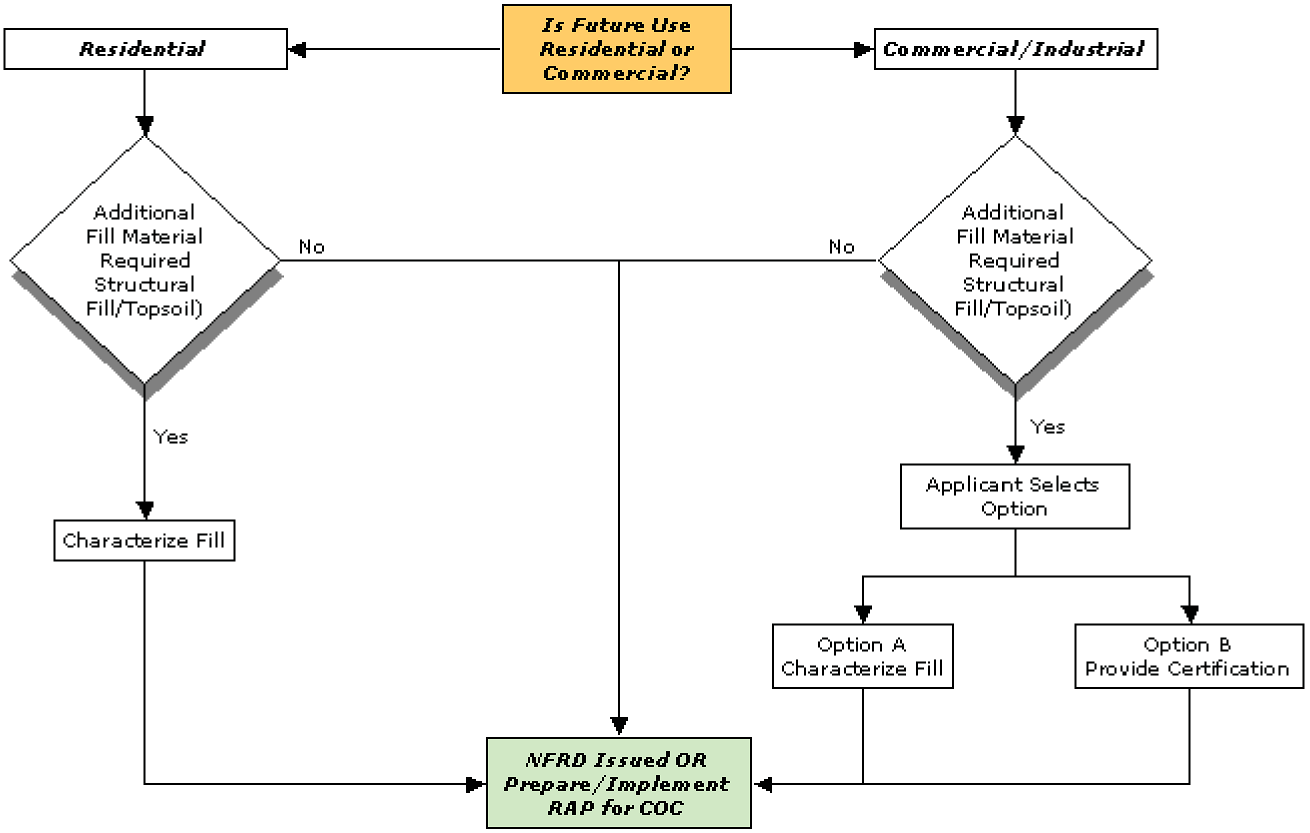
Depending upon the land use scenario, a VCP participant may be required to characterize the fill or provide a certification stating that the imported fill is not contaminated. As indicated in Exhibit 1, all imported fill materials for properties where the land use is determined to be residential must be characterized. In limited circumstances, the VCP may allow a participant to use imported fill material that has not been characterized for areas where no pathway will exist between the fill material and the property's end-users. In such circumstances, a Phase I Environmental Site Assessment conducted within a year from the date of scheduled delivery of fill material documenting that no recognized environmental conditions are present must be submitted to the VCP.

For commercial or industrial land uses, a VCP participant has the option of either characterizing the imported fill material or relying upon an affidavit from the vendor stating that the imported material has not been contaminated by controlled hazardous substances or oil. A template of the affidavit is attached to this guidance.

Selecting Fill Material

In general, the fill source area should be located in non-industrial areas, and not from sites undergoing an environmental cleanup. Non-industrial sites include those that were previously undeveloped, or used solely for residential or agricultural purposes. If the source is from an agricultural area, care should be taken to insure that the fill does not include pesticides, herbicides or metals. Unacceptable sources of fill material include industrial and/or commercial sites where

Exhibit 1: Use of Fill Material for Residential or Commercial/Industrial Decision Tree



hazardous materials were used, handled or stored as part of the business operations, or unpaved parking areas where petroleum hydrocarbons could have been spilled or leaked into the soil. Commercial sites to avoid include former gasoline service stations, retail strip malls that contained dry cleaners or photographic processing facilities, paint stores, auto repair and/or painting facilities, and agricultural supply stores. Industrial facilities to avoid include metal processing shops, manufacturing facilities, aerospace facilities, oil refineries, waste treatment plants, or other similar facilities.

Alternatives to using fill from construction sites include the use of fill material obtained from a commercial supplier of fill material or from soil pits in rural or suburban areas. However, care should be taken to ensure that those materials are also uncontaminated.

Table 1: Potential Contaminants Based on the Fill Source Area	
Fill Source	*Target Compounds/Recommended Analyses**
Land near to an existing highway	• Lead (EPA method 6020 [Rev 0 – 9/9]) • PAHs (EPA method 8270C [Rev 3 – 12/96)
Land near a mining area or rock quarry	• Heavy Metals (EPA method 6020 [Rev 0 – 9/9]) • Asbestos (polarized light microscopy) • pH
Agricultural land	• Pesticides (Organochlorine Pesticides: EPA method 8081A or 8080A; Organophosphorus Pesticides: EPA method 8141A; Chlorinated Herbicides: EPA method 8151A [Rev 1 – 12/96]) • Heavy Metals (EPA method 6020 [Rev 0 – 9/9])
Residential/acceptable commercial land	• VOCs (EPA Method 8260B (Rev 2 - 12/96); Note: The soil and sediment collection method has changed to EPA Method 5035) • SVOCs (EPA method 8270C) • TPH (modified EPA method 8015) • PCBs (EPA method 8082) • Heavy Metals including lead (EPA methods 6010B and 7471A) • Asbestos (OSHA Method ID-191)
*The recommended analyses should be performed in accordance with USEPA SW-846 methods (1996). Other possible analyses include Hexavalent Chromium: EPA method 3060A.	

Documentation and Analysis

In order to minimize the potential of introducing unacceptable fill material onto a site, it is necessary to verify through documentation that the fill source is appropriate and/or to have the fill material analyzed for potential contaminants based on the location and history of the source area. Fill documentation should include detailed information on the previous use of the land from where the fill is taken, whether an environmental site assessment was performed and its findings, and the results of any testing performed. It is recommended that an environmental professional, as defined by ASTM, should sign any such documentation. If such documentation is not available or is inadequate, samples of the fill material should be chemically analyzed. Analysis of the fill material should be based on the source of the fill and knowledge of the prior land use. The Department recommends using the analytical methods in Table 1 to determine whether potential contaminants are present in fill source areas.

Detectable amounts of compounds of concern within the fill material should be evaluated for risk in accordance with the *Soil and Groundwater Cleanup Guidance Document, August 2001*. A standard laboratory data package, including a summary of the QA/QC (Quality Assurance/Quality Control) sample results should also accompany all analytical reports. When possible, representative samples should be collected at the borrow area while the potential fill material is still in place, and analyzed prior to removal from the borrow area. In addition to performing the appropriate analyses of the fill material, an appropriate number of samples should also be determined based on the approximate volume or area of soil to be used as fill material. Table 2 can be used as a guide to determine the number of samples needed to adequately characterize the fill material when sampled at the borrow site.

Alternative Sampling

A Phase I environmental site assessment may be conducted prior to sampling to determine whether the borrow area may have been impacted by previous activities on the property. After the property has been evaluated, any sampling that may be required can be determined during a meeting with MDE. However, if it is not possible to analyze the fill material at the borrow area or determine that it is appropriate for use via a Phase I, it is recommended that the participant use Table 2 to determine the fill material sampling schedule. (See chart on Potential Contaminants Based on the Fill Source Area for appropriate analyses).

This sampling frequency may be modified upon consultation with the MDE if all of the fill material is derived from a common borrow area. However, fill material that is not characterized at the borrow area will need to be stockpiled either on or off-site until the analyses have been completed. In addition, should contaminants exceeding the criteria in *Soil and Groundwater Cleanup Guidance Document, August 2001* be identified in the stockpiled fill material, that material will be deemed unacceptable and new fill material will need to be obtained, sampled and analyzed. Therefore, MDE recommends that all sampling and analyses should be completed prior to delivery to the site to ensure the soil is free of contamination, and to eliminate unnecessary transportation charges for unacceptable fill material.

Composite sampling for fill material characterization may or may not be appropriate, depending on quality and homogeneity of source/borrow area, and compounds of concern. It is not acceptable to composite samples for volatile and semi-volatile constituents. Composite sampling for heavy metals, pesticides, herbicides or PAH's from unanalyzed stockpiled soil is also unacceptable, unless it is stockpiled at the borrow area and originates from the same source area. In addition, if samples are composited, they should be from the same soil layer, and not from different soil layers.

When very large volumes of fill material are anticipated, or when larger areas are being considered as borrow areas, MDE recommends that a Phase I be conducted on the area to ensure that the borrow area has not been impacted by previous activities on the property. After the property has been evaluated, any sampling that may be required can be determined during a meeting with MDE.

Table 2: Recommended Fill Material Sampling Schedule

Area of Individual Borrow Area	*Sampling Requirements*
2 acres or less	Minimum of 4 samples
2 to 4 acres	Minimum of 1 sample every 1/2 acre
4 to 10 acres	Minimum of 8 samples
Greater than 10 acres	Minimum of 8 locations with 4 sub samples per location
Volume of Borrow Area Stockpile	*Samples per Volume*
Up to 1,000 cubic yards	1 sample per 250 cubic yards
1,000 to 5,000 cubic yards	4 samples for first 1000 cubic yards +1 sample per each additional 500 cubic yards
Greater than 5,000 cubic yards	12 samples for first 5,000 cubic yards + 1 sample per each additional 1,000 cubic yards

Appendix F – Engineering Certification of South Warehouse Building Floor Slab as Soil Cap

ECS MID-ATLANTIC, LLC
"Setting the Standard for Service"
Geotechnical • Construction Materials • Environmental • Facilities

September 10, 2015

Mr. Raymond Goins
TC Harmans Road, LLC
c/o Trammell Crow Company
1055 Jefferson Street, NW, Suite 600
Washington, DC 20007

ECS Project No. 02-6387-C

Reference: Phase II Environmental Site Assessment
7555 and 7565 Harmans Road, Hanover, Maryland 21077

Dear Mr. Goins,

ECS Mid-Atlantic, LLC (ECS) received comments from the Maryland Department of the Environment (MDE) in response to a Response Action Plan (RAP) submitted by WSP USA Corp. for the subject site. In the letter the MDE requested that, 'the RAP be revised to include a signed statement from an engineer that the proposed construction of the building slab and parking areas intended as a cap are sufficient for the intended use."

BACKGROUND

In March 2014, WSP completed a remedial effort to address source area soils containing contaminants of concern in Area 1 and Area 2 as outlined in the Response Action Plan (RAP) for the site. During this remedial effort a total of 3,115.89 tons of impacted soil was excavated in Area 1 and 766.42 tons of impacted soil was excavated in Area 2. This soil was subsequently disposed of at a permitted facility offsite. The MDE reviewed the Response Action Plan Completion Report which documented this remedial action. According to the MDE, these remedial actions adequately document the activities set forth in the Response Action Plan (RAP) which the MDE approved for the site.

As part of this soil excavation activity, a shoring system was designed that allowed for the maximum amount of affected soil to be removed while protecting the structural integrity of the building. However, according to WSP, based on the supplemental soil sampling data, some low residual levels of site related VOCs remain in the vadose zone soil beneath the building floor slab in Area 1 and in Area 2.

FUTURE SITE USE

The development of the property will involve the demolition of the existing onsite structures and the construction of two warehouse buildings separated by a truck loading area. The concrete slab for the existing building in the vicinity of Area 1 and Area 2 will remain in place and the concrete floor associated with the future warehouse will be installed over the current slab. The proposed concrete slab of the future warehouse will be a minimum of 4 to 6 inches in thickness. The existing building floor slab will be removed in the proposed loading dock area between the buildings. For this inter-building area, new surface pavement consisting of both concrete and heavy duty asphalt will be emplaced and serve as the paved surface for the truck loading and unloading activities. The thickness of the new concrete pavement adjacent to the warehouse buildings will be 6 inches over 6 inches of graded aggregate base. The asphalt will be installed for the remaining portion of the loading dock area and will have a thickness of 6 inches over 6 inches of graded aggregate base.

CONCLUSION

Based upon VOC concentrations identified in the remaining vadose soil onsite as well as the implementation of a Site Maintenance Plan, the proposed construction of the concrete building slab as well as the concrete and asphalt pavement as a cap for the impacted soil are sufficient for the intended use of the site as commercial.

In the event that the damage to the cap is identified during the implementation of the Site Maintenance Plan, the damage will need to be assessed and repairs made as needed to maintain the effectiveness of the cap.

ECS appreciates the opportunity to work with you on this project. If you have any questions regarding this report or other topics, please feel free to contact us at (410) 859-4300.

Respectfully,

ECS Mid-Atlantic, LLC

HASAN M. ABOUMATAR
No. 29553

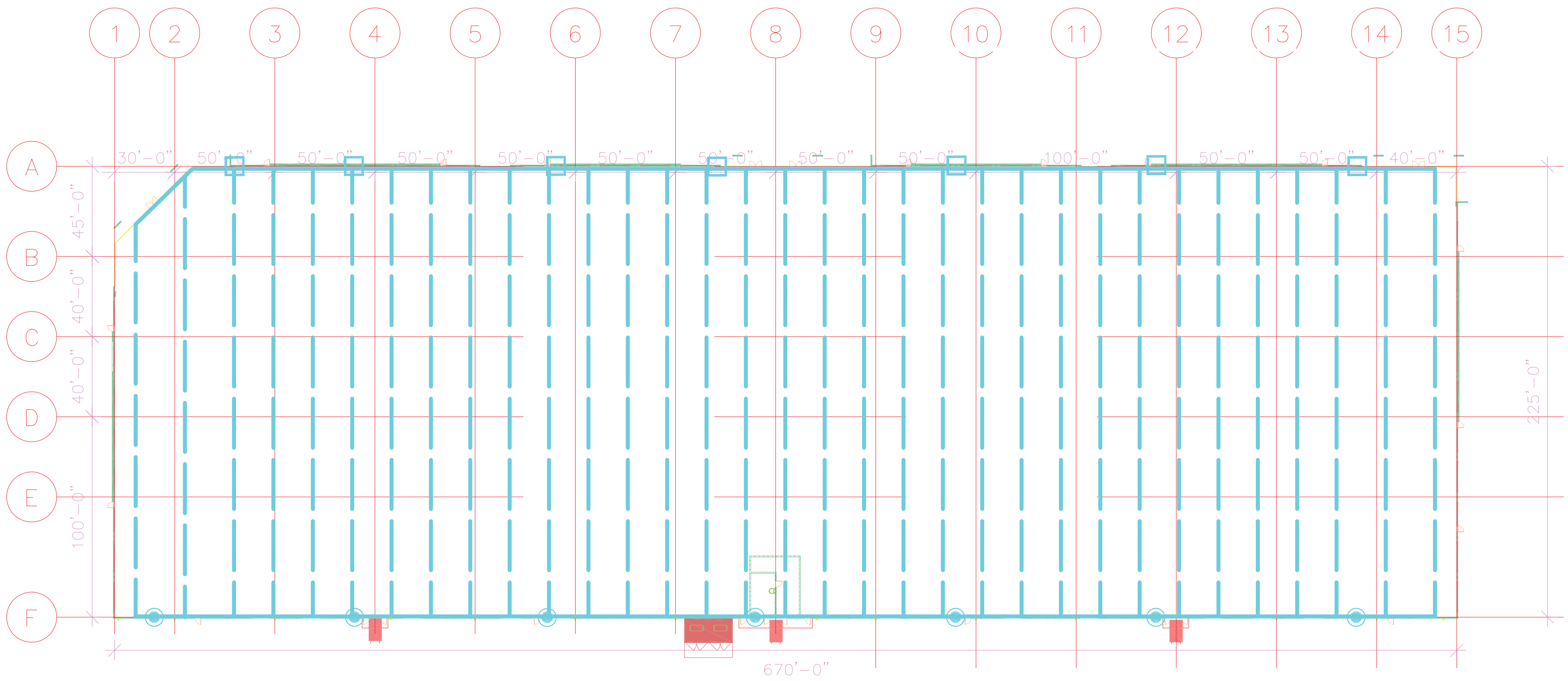
Hasan Aboumatar, PhD, P.E.
Geotechnical Manager

Michael Bell
Project Manager

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the state of Maryland.

License No. ***29553*** , Expiration Date: ***12/31/2015***

Appendix G – Sub-Slab Vapor Venting System Plans and Specifications



North Building

LEGEND

- ▬ ▬ – 2" DIAM. PERFORATED PIPE
- ▬▬ – 4" DIAM. PERFORATED PIPE
- ☐ – FRESH AIR INTAKE (7 LOCATIONS)
- ◉ – VENT TO THE ROOF (7 LOCATIONS)

NO.	REVISIONS	DATE

Sub–Slab Vapor Venting System
Kop–Flex Site (North Building Layout)
7555 and 7565 Harmans Road
Harmans, Maryland

TC Harmans Road, LLC

MMB	HMA	04/02/2015	6387–F	1 OF 4

ECS MID–ATLANTIC, LLC
1340 CHARWOOD ROAD, SUITE A
HANOVER, MARYLAND 21076
OFFICE (410) 859–4300
FAX (410) 859–4324
"Setting The Standard For Service"

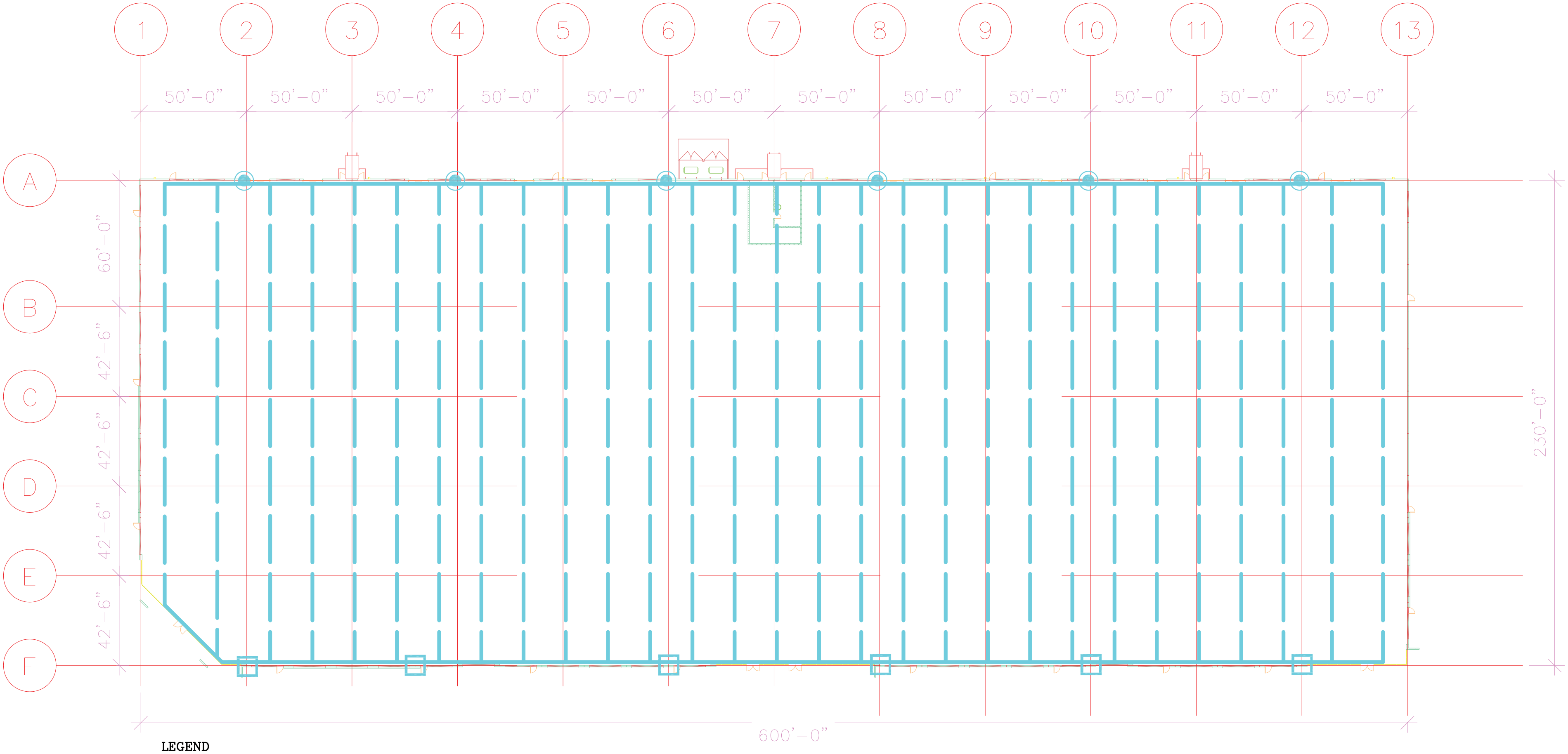
Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland.

License No. 29553, Expiration Date: 12/31/15

HASAN M. ABOUMATAR
NO. 29553

H. Aboumatar

HASAN M. ABOUMATAR, P.E.



LEGEND

- ▬ ▬ ▬ – 2" DIAM. PERFORATED PIPE
- ▬▬▬ – 4" DIAM. PERFORATED PIPE
- ☐ – FRESH AIR INTAKE (6 LOCATIONS)
- ◉ – VENT TO THE ROOF (6 LOCATIONS)

South Building

NO.	REVISIONS	DATE

Sub–Slab Vapor Venting System
Kop–Flex Site (South Building Layout)
7555 and 7565 Harmans Road
Harmans, Maryland

TC Harmans Road, LLC

MMB	HMA	04/02/2015	6387–F	2 OF 4

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland.

License No. 29553, Expiration Date: 12/31/15

NO. 29553
HASAN M. ABOUMATAR
H. Aboumatar
HASAN M. ABOUMATAR, P.E.

ECS MID–ATLANTIC, LLC
1340 CHARWOOD ROAD, SUITE A
HANOVER, MARYLAND 21076
OFFICE (410) 859–4300
FAX (410) 859–4324
"Setting The Standard For Service"

VAPOR VENTING SYSTEM DESIGN SPECIFICATIONS

PART 1: GENERAL

1.01 DESCRIPTION

A. WORK INCLUDES FURNISHING AND INSTALLING VAPOR VENTING SYSTEM TO THE LINES, GRADES AND SPACING SHOWN ON THE CONSTRUCTION DRAWINGS AND AS SPECIFIED HEREIN.

B. WORK INCLUDES SEALING ALL UTILITY PENETRATIONS THROUGH THE SLAB AND FOUNDATION SYSTEM TO MITIGATE VAPOR PATHWAYS FROM PERIMETER UTILITIES ENTERING BUILDING AND FROM BENEATH BUILDING.

1.02 QUALITY ASSURANCE

A. ECS SHOULD BE NOTIFIED DURING THE CONSTRUCTION AND INSTALLATION OF THE VAPOR VENTING SYSTEM SO THAT CONDITIONS CAN BE DOCUMENTED PRIOR TO THE PLACMENT OF THE VAPOR BARRIER.

B. CONTRACTOR SHALL CHECK THE MATERIALS UPON DELIVERY TO ASSURE THAT PROPER MATERIALS HAVE BEEN RECEIVED.

C. CONTRACTOR SHALL PROTECT THE MATERIALS FROM DAMAGE. DAMAGED MATERIALS SHALL NOT BE INCORPORATED INTO THE VAPOR VENTING SYSTEM AND SHALL BE REPLACED.

PART 2: MATERIALS

2.01 VAPOR VENTING SYSTEM

A. LOCATION OF VENTING PIPE LINES MAY BE MOVED 2' IN ANY HORIZONTAL DIRECTION TO AVOID UNDERGROUND UTILITIES OR FOUNDATIONS. MAINTAIN 3" CLEARANCE OF PIPE FROM FOUNDATIONS, WALLS, AND COLUMNS (WITH THE EXCEPTION OF INTAKES/RISERS AND ASSOCIATED CONNECTIONS).

B. ALL UNDERSLAB VENT PIPE SHALL BE 2" I.D. SLOTTED OR PERFORATED SCHEDULE 40. PVC. SLOTS IN THE GAS COLLECTION PIPING SHALL FACE DOWNWARD ALLOWING ANY MOISTURE TO DRAIN.

C. COLLECTION PIPES AND VENT RISERS SHALL BE 4" SOLID PVC ENCASED IN IRON PIPE OR OTHER PROTECTION MECHANISM WHERE EXPOSED.

D. PLACEMENT OF RISER PIPE SHALL BE AS CLOSE TO THE COLUMN/WALL AS POSSIBLE. ANY JOGS IN THE RISER PIPE SHOULD MAINTAIN AN UPWARD SLOPE. (i.e., NO HORIZONTAL OR DOWNWARD TURNS OR SLOPES)

E. END CAPS FOR UNDERSLAB VENT PIPE SHALL BE GLUED AND SEALED WITH SUITABLE ELASTOMERIC PIPE CEMENT.

F. ROOF VENTS SHALL NOT BE LOCATED WITHIN 10 FEET OF OTHER VENTS FOR AIR HANDLING OR VENTILATION SYSTEMS, OR SPARKING SOURCES. REFER TO HVAC DRAWINGS FOR TYPICAL ROOF PENETRATION DETAILS.

B. A MINIMUM 4" OF AGGREGATE SUBBASE WITH ADEQUATE PORE SPACE SHALL BE UTILIZED. (AASHTO #57 STONE OR EQUAL, WITH LESS THAN 5% FINES)

D. ALL EXPOSED PIPING IN BUILDING SHALL BE LABELED "VENT SYSTEM DO NOT TAMPER".

2.02 VOLATILE ORGANIC COMPOUND/HYDROCARBON RESISTANT BARRIER (VOC/HRB)

A. PRIOR TO SLAB PLACEMENT, INSTALL MIN. 20 MIL POLY VAPOR BARRIER (VAPOR BLOCK 20 OR EQUAL).

B. EDGES OF VAPOR BARRIER SHOULD BE OVERLAPPED A MINIMUM OF 1.0 FEET.

C. EDGE OF BARRIER SHALL BE SEALED WITH COMPATIBLE TAPE. ALL PENETRATIONS SHALL ALSO BE SEALED WITH COMPATIBLE TAPE.

PART 3: EXECUTION

3.01 VAPOR VENTING SYSTEM INSTALLATION NOTES

A. CONTRACTOR SHALL EXCAVATE TO THE LINES, GRADES, AND SPACING SHOWN ON THE CONSTRUCTION DRAWINGS.

B. PVC SECTIONS SHOULD BE CUT TO LENGTH AND GLUED WITH COUPLINGS AS NEEDED.

C. EXACT VENT TO ROOF LOCATIONS SHOULD BE DETERMINED IN THE FIELD WITH OWNER, ARCHITECT AND CONTRACTOR. WALL VENT STACKS SHOULD BE AIR TIGHT

D. IN THE EVENT THAT UTILITIES OR OTHER CONSTRUCTION ELEMENTS INTERFERE WITH THE CONCEPTUAL LAYOUT OF THE VAPOR VENTING SYSTEM, ECS SHOULD BE NOTIFIED.

E. THE HORIZONTAL PERFORATED PIPING SHALL BE INSTALLED FLUSH TO THE POLY BARRIER AND A MIN. 2" ABOVE THE SUBGRADE.

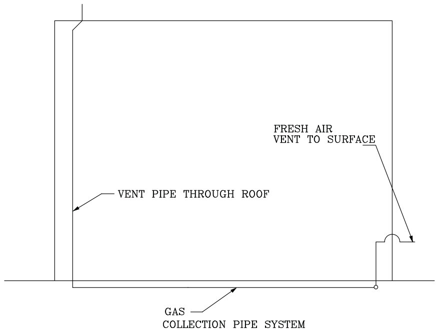
F. PRIOR TO PLACEMENT OF VOC/HRB, ECS SHALL BE NOTIFED AND PIPING SYSTEM OBSERVED.

G. PRIOR TO THE PLACEMENT OF CONCRETE SLAB, ECS SHALL BE NOTIFIED TO OBSERVE AND DOCUMENT PLACEMENT OF VOC/HRB.

H. UPON COMPLETION OF VAPOR BARRIER, EXTREME CARE SHOULD BE TAKEN TO PREVENT PUNCTURE. CONTRACTOR SHALL REPAIR ALL PUNCTURES JUST BEFORE SLAB PLACMENT, ECS SHALL BE ON SITE TO DOCUMENT CONDITION OF VAPOR BARRIER, DURING SLAB PLACMENT. PENATRATIONS IN THE VAPOR BARRIER WILL REQUIRE REPAIR PRIOR TO CONCRETE SLAB INSTALLATION

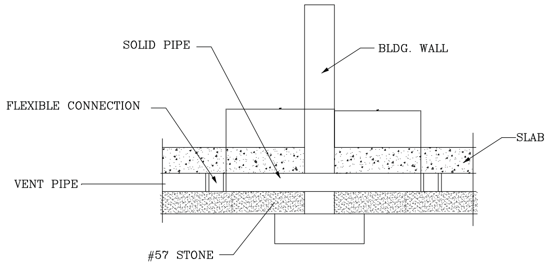
NOTES:

1. ALL OPENING, GAPS, AND JOINTS IN FLOOR AND WALL ASSEMBLIES IN CONTACT WITH SOIL OR GAPS AROUND PIPES, OR DRAINS PENETRATING THESE ASSEMBLIES SHALL BE FILED OR CLOSED WITH MATERIALS THAT PROVIDE A PERMANENT AIR-TIGHT SEAL. SEAL LARGE OPENINGS WITH NON-SHRINK MORTAR, GROUTS, OR EXPANDING FOAM MATERIALS AND SMALLER GAPS WITH AN ELASTOMERIC JOINT SEALANT, SICKAFLEX OR EQUIVALENT AS DEFINED IN ASTM C920-87.
2. A 20 MIL VOC AND HYDROCARBON RESISTANT VAPOR BARRIER SHALL BE PLACED OVER STONE PRIOR TO SLAB PLACMENT. (VAPOR BLOCK 20 OR EQUAL).
3. PIPES AND PERFORATIONS SHALL BE INSTALLED SO THAT ANY RAINWATER OR CONDENSATION DRAINS DOWNWARD INTO THE GROUND BENEATH THE SLAB AND VAPOR BARRIER.
4. ANY UTILITY CONNECTIONS BENEATH THE ONSITE STRUCTURE WHICH ALSO ENTER THE ONSITE STRUCTURE SHOULD BE AIR TIGHT.
5. SYSTEM MAINTENANCE SHALL INCLUDE INSPECTION AND REPAIR (AS NECESSARY) OF ALL SEALED SLAB JOINTS AND PENETRATIONS, ROOF VENTS, AND INTAKE VENTS ANNUALLY.



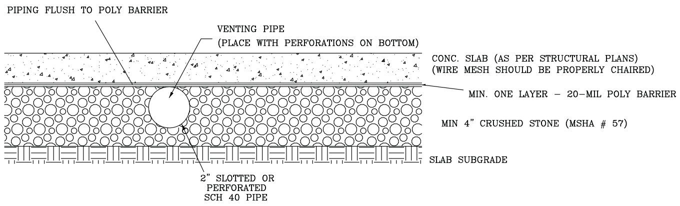
SCHEMATIC DESIGN DIAGRAM

NOT TO SCALE



TYPICAL VENT PIPE THROUGH BUILDING WALL

NOT TO SCALE



BELOW SLAB INSTALLATION

NOT TO SCALE

NO.	REVISIONS	DATE

Sub-Slab Vapor Venting System
Notes and Details
Kop-Flex Site
7555 and 7565 Harmans Road, Harmans, MD

TC Harmans Road, LLC

MMB	HMA	04/02/2015	6387-F	3 OF 4

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland.

License No. 29553, Expiration Date: 12/31/15

HASAN M. ABOUMATAR
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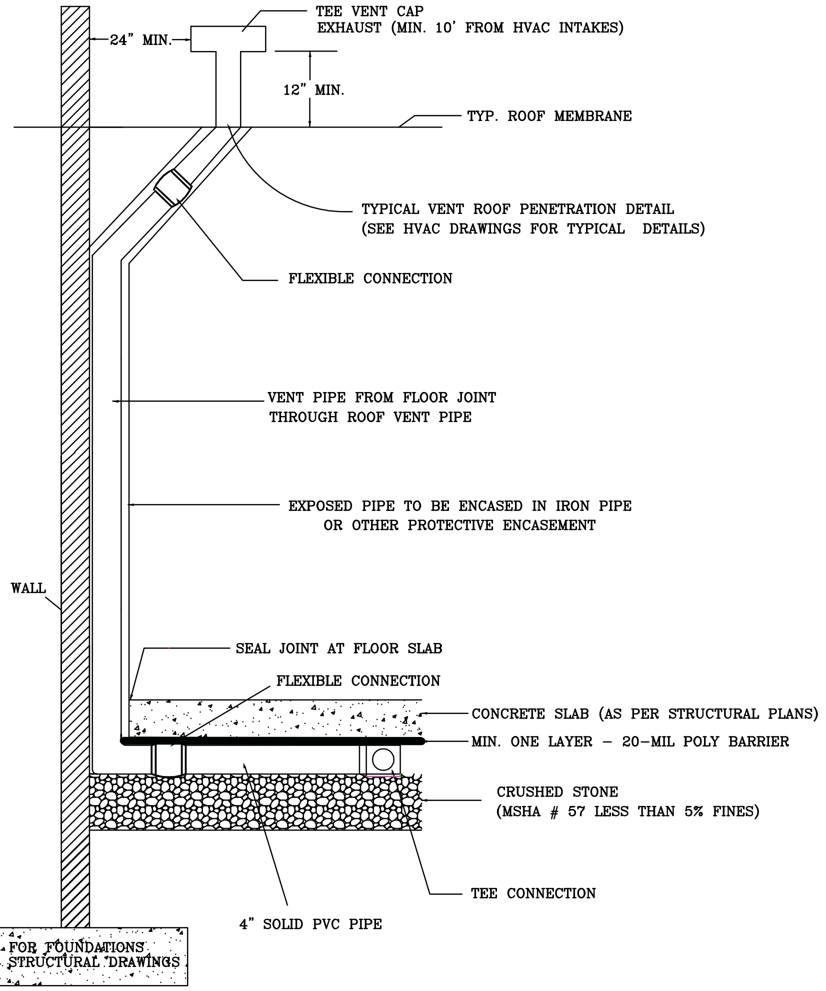
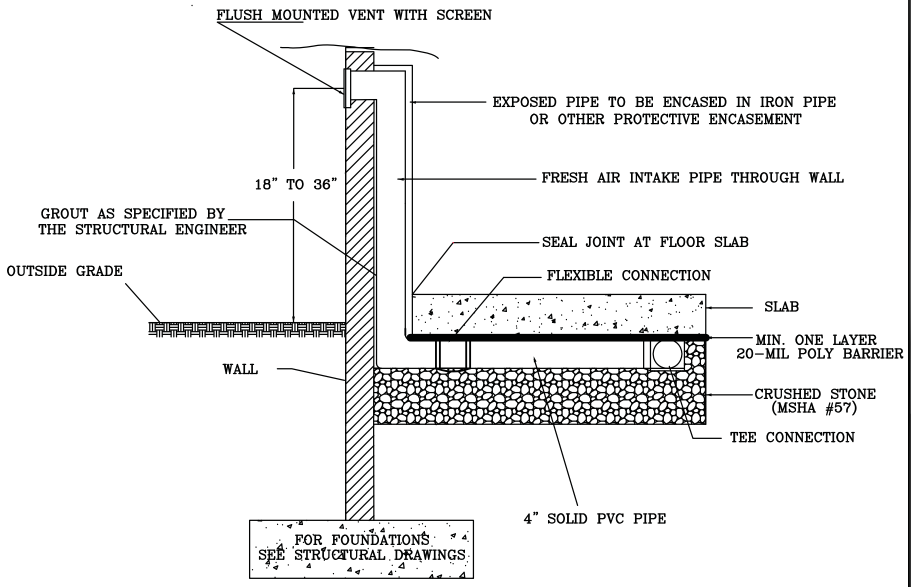
"Setting The Standard For Service"



RISER PIPE DETAIL – TYPICAL OUTLET

NOT TO SCALE



INTAKE PIPE DETAIL – TYPICAL INTAKE

NOT TO SCALE

NO.	REVISIONS	DATE

Sub–Slab Vapor Venting System
Riser Details
Kop–Flex Site
7555 and 7565 Harmans Road, Harmans, MD

TC Harmans Road, LLC

MMB	HMA	04/02/2015	6387–F	4 of 4

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland.

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"Setting The Standard For Service"

Appendix H – Groundwater Monitoring Plan

Groundwater Monitoring Plan

Former Kop-Flex Facility
Hanover, Maryland

September 17, 2015 Revision 1.0

Project No. E0003705

GROUNDWATER MONITORING PLAN

Former Kop-Flex Facility, Hanover, Maryland

September 17, 2015

Client

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Appendix B – WSP Standard Field Operating Procedures

Appendix C – HydraSleeve Standard Operating Procedure

1 Introduction

This Groundwater Monitoring Plan (GWMP) for the former Kop-Flex Voluntary Cleanup Program (VCP) site in Hanover, Maryland, was prepared by WSP USA Corp. as part of the Response Action Plan (RAP) for the site. The plan was developed following the guidelines presented in the U.S. Environmental Protection Agency (EPA) guidance document titled "*Guidance for Monitoring at Hazardous Waste Sites: Framework for Monitoring Plan Development and Implementation"* USEPA 2004 and other applicable USEPA and Maryland Department of the Environment (MDE) technical guidance and procedures.

All field activities performed as part of the groundwater monitoring program will be conducted in accordance with the current version of the Health and Safety Plan (HASP) for the site (WSP 2013). Any information relevant to the planned monitoring activities that has not been provided in the previous submittals to MDE is included in this GWMP.

2 Site Background

2.1 Site Description

The former Kop-Flex site is located at 7565 Harmans Road in Hanover, Anne Arundel County, Maryland. The facility occupies an approximately 25-acre parcel and consists of two buildings – an approximately 220,000-square-foot former manufacturing and office building and an approximately 20,000-square-foot former forge building near the eastern property boundary. The property is bordered to the north by a Verizon Communications maintenance facility; to the east by the Williams-Scotsman facility followed by railroad tracks; to the south by the Williams-Scotsman facility followed by Maryland State Route 100; and to the west by undeveloped land along Stony Run, a tributary of the Patapsco River, followed by Harmans Road and a residential area.

The elevation of the site varies from approximately 108 feet mean sea level (ft msl) along the drainage channel and flood plain for Stony Run to 130 ft msl in the southeast corner of the property. The closest surface water body is Stony Run, which crosses the northwestern portion of the site. This stream flows northward and eventually discharges into the Patapsco River, which is located 7 miles from the site. In addition to this stream, several small pond areas have been identified and mapped in the vicinity of the site.

2.2 Geology and Hydrogeology

The site lies within the Atlantic Coastal Plain physiographic province. In Anne Arundel County, Maryland, this province is characterized by alternating layers of predominately sand and clay sediments of Cretaceous age. Based on regional hydrogeologic cross-sections for these sedimentary deposits, the inter-layered sequence of sand and clay units dips gently to both the south and east from the north part of the county. In Anne Arundel County, the Coastal Plain deposits range in thickness from a few tens of feet along the northwestern boundary with Howard County to as much as 2,500 feet in southeastern Anne Arundel County (Vroblesky and Fleck, 1991). The complexly stratified deposits comprising the Atlantic Coastal Plain form an inter-layered sequence of aquifers and confining beds. The upper-most water-bearing unit is typically represented by a surficial water-bearing zone consisting of Quarternary alluvium and shallow subsurface deposits of the Lower Patapsco aquifer. This surficial zone is underlain by several confined aquifers that include the Patuxent, lower and upper Patapsco, and Magothy. These aquifers may be considered unconfined over their outcrop areas and confined in the direction down-dip from the outcrop and subcrop areas, although the confining units may thin and be regionally discontinuous.

An evaluation of borehole lithologic data obtained from field investigations indicates the coastal plain deposits at the site comprise a complexly inter-bedded sequence of predominately coarse-grained (sand with gravel and fines) and fine-grained (silt and clay) units. Given the spatial and vertical heterogeneity typical of the Atlantic Coastal Plan deposits, the unconsolidated materials have been grouped into three gross stratigraphic units, which are generically termed “upper,” “middle,” and “lower” (Figure 1). The Upper Stratigraphic Unit is comprised primarily of sand, with variable fines content, to gravelly sand along with occasional discontinuous silt and clay lenses of variable extent and thickness. This upper sandy unit appears to be thickest in the eastern portion of the site and thins to the west. The Upper Stratigraphic Unit is underlain by the Middle Stratigraphic Unit, which is characterized by zones of coarse-grained (sand to clayey sand) and fine-grained (silty to sandy clay to clayey to sandy silt to finely inter-laminated sand and clay) sediments exhibiting variable thickness and noticeable lateral and vertical heterogeneity. From northwest to southeast across the site, the lithologic characteristics of this unit transition from a thick (20 to 30-foot) sand interval bounded above and below by silt and clay deposits to an area of inter-bedded and inter-fingering coarse and fine-grained deposits underneath the eastern portion of the manufacturing building to an very thick (approximately 65 feet) sequence of predominately silt and clay deposits in the southern-most portion of the site. A locally continuous layer of hard, dense silty clay to clayey silt sediments layer exits at a depth of approximately 60 feet at the site. The Lower Stratigraphic Unit consists primarily of sand and gravelly sand deposits with occasional discontinuous layers of inter-mixed clay and silt sediments of variable thickness. Based on evaluation of the lithologic data, the top of this unit occurs at depths ranging from approximately 50 feet below ground surface (bgs) in the northwest portion of the site to approximately 100 feet bgs near the southeastern corner of the property.

Based on the textural variation of the three stratigraphic units and their associated permeability, the predominately coarse-grained sediments comprising the upper and lower units and the thick sand interval within the middle unit represent the primary zones for groundwater flow at the site. The unconsolidated deposits of the upper and middle units at depths ranging from approximately 45 feet in the north to 60+ feet in the south constitute the shallow water-bearing zone, or Surficial aquifer, within the hydrogeologic system. The lower unit is inferred to be upper portion of the semi-confined Lower Patapsco aquifer. Hard silt and clay deposits of the Middle Stratigraphic Unit form a leaky aquitard that hydraulically separates the unconfined Surficial and semi-confined Lower Patapsco aquifers. Overall, flow paths within the fine-grained deposits of the Middle Stratigraphic Unit are complex and involve predominately vertical (downward) movement of groundwater.

For the Surficial aquifer, groundwater occurs under an unconfined condition in the coarse-grained deposits of the Upper Stratigraphic Unit. Given the presence of appreciable clayey deposits in the shallow subsurface in the northern and western portions of the site, groundwater within the sand lenses and thick sand layer within the Middle Stratigraphic Unit occurs under a partially, or semi-, confined condition. Flow within the Surficial aquifer is in a west to northwest direction toward Stony Run (Figure 2). Groundwater discharge within the upper-most sand units and deeper (partially confined) sand deposits is believed to provide base flow to Stony Run. Groundwater in the deeper portion of the Lower Patapsco aquifer also occurs under semi-confined conditions. Based on water level data from site monitoring wells, the direction of groundwater flow in the Lower Patapsco aquifer is to the south-southeast, which is consistent with published studies of the Coastal Plain Aquifer System in Anne Arundel County, Maryland (Figure 3). The significant head differences in monitoring wells completed at depths of less than and greater than 60 feet bgs indicate that the hard silt and clay layer serves as an aquitard, between the unconfined Surficial and semi-confined Lower Patapsco aquifers in the hydrostratigraphic sequence. However, spatial variations in the lithology and thickness of the sediments comprising the aquitard and associated sedimentary structures within the fine-grained deposits may provide mechanisms for the vertical leakage of groundwater to the Lower Patapsco sand deposits.

2.3 Groundwater Quality

2.3.1 Surficial Aquifer

The chemicals of concern (COCs) in the Surficial aquifer consist of chlorinated volatile organic compounds (VOCs), primarily the following:

- 1,1,1-trichloroethane (TCA)
- degradation products of 1,1,1-TCA such as 1,1-dichloroethene (1,1-DCE) and 1,1-dichloroethane (DCA)
- chlorinated ethenes such as trichloroethene (TCE) and tetrachloroethene (PCE)
- 1,4-dioxane

In general, the highest VOC levels in shallow groundwater are found in the identified source areas in the southwest portion of the manufacturing building and to the east of the manufacturing building and decrease in the direction of groundwater flow. VOC impacts in shallow groundwater extend from the vicinity of wells MW-02, MW-11, MW-12 and MW-16, which are located to the east of the manufacturing building, to the area west of the manufacturing building at MW-18 and MW-39. Although VOCs were detected in wells near the eastern property boundary (MW-04, MW-08, and MW-20), the concentrations are substantially lower than VOC concentrations found in wells located in close proximity to the source area to the immediate east of the building.

VOC’s associated with the source area east of the building have migrated westward (downgradient) below the manufacturing building and commingled with constituents associated with the source area below the southwest portion of the building. Figure 4 depicts the total VOC distribution in the Surficial aquifer at the site. In the area west of the manufacturing building, VOC concentrations are higher in samples collected from the shallow wells screened in the upper clayey deposits than in samples collected from slightly deeper wells completed in the underlying sand unit (MW-14, MW-18 and MW-39). No site-related COCs have been detected at levels of concern in samples from shallow well MW-03 northwest of the manufacturing building. Based on evaluation of the sampling data, no site-related VOCs are migrating offsite in the shallow portion of the groundwater system.

2.3.2 Lower Patapsco Aquifer

The COCs in the Lower Patapsco aquifer are consistent with those identified in the shallow water-bearing zone: 1,1,1-TCA and its degradation products, chlorinated ethenes, and 1,4-dioxane. An iso-concentration map showing the total VOC distribution in the deeper aquifer is shown in Figure 5. Overall, VOC impacts in deeper groundwater extend from the identified source area to the east of the manufacturing building to the south-southeast (downgradient) beyond the Kop-Flex property boundary. As indicated in the plume map, total VOC concentrations greater than 500 micrograms per liter (µg/l) are present at well MW-17D, which is located immediately south of the source area, and in samples from downgradient wells MW-1D (onsite) and MW-24D (offsite). Wells MW-19, MW-23D, and MW-27D are located hydraulically upgradient of the area where VOCs enter the Lower Patapsco aquifer at the site. Trace to non-detect levels of site-related VOCs are present in samples collected from MW-19 and MW-27D. Well MW-23D, which is locate approximately 350 feet north of the eastern source area, contains low levels of site-related VOCs such as 1,1-DCE and 1,4-dioxane. Although these VOCs are consistent with the identified site COCs, the presence of these compounds some distance upgradient of the highest concentrations are believed to reflect the influence of transient migration pathways different from those in the hydrogeologic system.

3 Groundwater Monitoring Program

3.1 Cleanup Criteria for Chemicals of Concern

The cleanup criteria for all site-related COCs, except for 1,4-dioxane, are equivalent to the promulgated MDE groundwater quality standards, and are listed below.

- 1,1,1-TCA – 200 µg/l
- 1,1-DCE – 7 µg/l
- 1,2-DCA – 5 µg/l
- 1,1-DCA – 90 µg/l
- Chloroethane – 3.6 µg/l
- *cis*-1,2-DCE – 70 µg/l
- TCE – 5 µg/l
- PCE – 5 µg/
- Vinyl chloride – 2 µg/l

These values correspond to the standards for Type I and II aquifers, and maximum contaminant levels (MCLs) and secondary MCLs developed by USEPA under the Safe Drinking Water Act. Based on the site hydrogeologic and hydrogeochemical data, both the Surficial and Lower Patapsco aquifer meet the definitions of a Type I aquifer provided in the document *Cleanup Standards for Soil and Groundwater, Interim Final Guidance (Update No. 2.1)* (MDE 2008).

At present, no groundwater quality standard has been promulgated for 1,4-dioxane. Using the current default exposure factors developed by USEPA and a target cancer risk of 1E-5, WSP calculated a risk-based criterion for 1,4-dioxane is 7.8 µg/l. Given the depth to groundwater and planned implementation of groundwater use restrictions on the property, the direct ingestion exposure pathway for 1,4-dioxane would be incomplete for potential onsite receptors. As discussed in Section 2.3.1, evaluation of the monitoring well sampling data indicates 1,4-dioxane concentrations below the risk-based criterion in shallow groundwater seepage to Stony Run. In addition, any detectable concentrations of 1,4-dioxane in water discharging to Stony Run would rapidly decrease in response to mixing with surface water flow from upstream areas south of the site. Given these conditions, WSP has proposed an alternate, property-specific cleanup criterion of 15 µg/l, or approximately 2x the calculated risk-based level of 7.8 µg/l, for the site.

3.2 Abandonment of Existing Wells

Based on the development plan for the property, monitoring wells situated within the planned footprint of the new buildings and truck dock areas will need to be abandoned to facilitate the future construction activities. In addition, WSP plans to decommission wells within the loading dock area, except for the MW-16/MW-16D well pair, due to health and safety (H&S) hazards associated with working in an area with a high volume of truck traffic, and selected wells situated in other portions of the property.

The utility plan for the property development will necessitate the relocation of wells MW-05-31 and MW-38-28. The relocation of these monitoring points will involve the abandonment of the existing wells and installation of similarly designed and constructed replacement wells (MW-05R and MW-38R) in the immediately surrounding area. Each replacement well would be installed a minimum distance of 10 feet from any subsurface utility lines.

Figure 6 shows the locations of the existing monitoring wells to be abandoned at the site, together with an overlay of the planned property development. All wells will be decommissioned in accordance with the applicable Maryland well construction regulations. Additional information concerning the well abandonment procedures is provided in Section 4.

3.3 Monitoring Network

3.3.1 Groundwater Level Measurements for Assessing Hydraulic Containment

3.3.1.1 Surficial Aquifer

Water level data will be collected from the remaining monitoring wells at the site. In addition, three new wells – MW-42, MW-43, and MW-44 – will be installed cross and downgradient of the extraction well system near the inferred limits of the VOC plume in the Surficial Aquifer. (Information on the installation of these proposed wells is provided in Section 4.) These data will be augmented by measurements at the extraction wells and the new monitoring well (MW-45) to be installed on the Williams-Scotsman property following completion and evaluation of the depth-discrete sampling data from the WSP-95 location (see Section 3.3 of RAP). Table 1 lists the wells to be included in the water level monitoring network for the Surficial aquifer. The locations of these monitoring points (excluding the MW-45 location) are shown in Figure 7. Water level measurements from the new wells will be used to evaluate hydraulic containment of affected groundwater extending west of the building area. Groundwater elevations calculated from the depth to water measurements will be contoured using geostatistical methods to determine aquifer drawdown and assess capture effectiveness in response to withdrawals from the extraction wells.

The water level data for the extraction wells RW-1S, RW-2S, and RW-3S will be used to approximate aquifer drawdown during remedial pumping and check for declines in the specific capacity for each well during system operation. The specific capacity of a pumping well is the yield per unit drawdown, and is calculated using the following relationship (Heath 1987):

$$\text{Specific capacity} = \text{pumping rate/drawdown} = Q/S_w$$

where Q is the pumping rate and S_w is the drawdown. Significant reductions in the recovery well specific capacity may indicate possible encrustation, clogging, or fouling of the screen and/or sand filter pack, and the need to perform maintenance activities to rehabilitate the well.

3.3.1.2 Lower Patapsco Aquifer

Water level data will be collected from all of the remaining deep monitoring wells and offsite well MW-24D on the Williams-Scotsman property. In addition to the existing wells, two new monitoring wells (MW-40D and MW-41D) will be installed near the southern property boundary. (Information on the installation of this proposed monitoring well is provided in Section 4.) These data will be augmented by measurements at extraction wells RW-1D and RW-2D installed within the area of VOC plume. Table 1 lists the monitoring wells to be included in the water level monitoring network for the Lower Patapsco aquifer. The locations of these monitoring points are shown in Figure 8. Water level measurements from these new wells will be used to evaluate hydraulic containment of the affected groundwater extending to off-property areas.

Groundwater elevations determined for the wells will be contoured using geostatistical methods to determine aquifer drawdown and assess capture effectiveness in response to extraction well pumping. Additionally, the water level elevations for well MW-41D will be compared with MW-21D to determine the presence of vertical hydraulic gradients in response to pumping from the extraction wells along the southern property boundary.

As with the shallow extraction wells, the water level data for deep extraction wells RW-1D and RW-2D will be used to approximate aquifer drawdown during remedial pumping and check for declines in the specific capacity for each well during system operation. Significant reductions in the recovery well specific capacity may indicate possible encrustation, clogging, or fouling of the screen and/or sand filter pack, and the need to perform maintenance activities to rehabilitate the well.

3.3.2 Groundwater Monitoring for Assessing Remedy Effectiveness

3.3.2.1 Surficial Aquifer

The three shallow extraction wells (RW-1S, RW-2S, and RW-3S), along with selected existing wells (MW-03, MW-04, MW-05R, MW-09, MW-16, MW-20, MW-38R and MW-39) and new wells MW-42, MW-43, MW-44, and MW-45 on the Williams-Scotsman property, will be used to monitor and evaluate the performance of the hydraulic containment system for the Surficial aquifer. Figure 9 indicates the wells comprising the groundwater quality monitoring network (except for MW-45) with respect to the inferred area of VOC-impacted on the property. A summary of pertinent construction information for the existing and proposed monitoring points (excluding MW-45) is presented in Table 2. In this table, the selected wells are identified into those monitoring for hydraulic containment of the VOC-affected groundwater and for mass removal from the impacted aquifer.

3.3.2.2 Lower Patapsco Aquifer

Deep extraction wells RW-1D and RW-2D, together with eight monitoring wells (including new wells MW-40D and MW-41D), will be used to collect groundwater quality samples from the Lower Patapsco aquifer to evaluate the performance of the hydraulic containment system. The locations of the wells comprising the groundwater quality monitoring network in the deep aquifer with respect to the inferred VOC plume are shown in Figure 10. Well construction information for the existing monitoring points is provided in Table 3. In this table, the selected wells are identified into those for monitoring hydraulic containment of the VOC-affected groundwater and mass removal of the impacted aquifer.

3.4 Monitoring Frequency

3.4.1 Groundwater Levels

3.4.1.1 Base-line Monitoring Event

A synoptic round of depth to water measurements will be gathered from the wells comprising the water level monitoring network in each aquifer no more than 48 hours before the start of pumping from the extraction wells in the respective water-bearing zone. The water levels in the monitoring wells will be manually measured using an electronic water level indicator. Groundwater level elevations will be determined from the field measurements and survey information for each well. The elevation data will be contoured using geostatistical methods (kriging) to characterize the static, or non-pumping, groundwater surface at the site. These data will also be used to determine the drawdown in the pieziometric surfaces in both aquifers in response to groundwater withdrawals during system operation.

3.4.1.2 Remedial System Start-up and Initial Operation

During the initial week of startup, the monitoring wells included in the water level monitoring networks for each aquifer comprise two groups with respect to the measurement frequency. The first group will consist of monitoring points located in the vicinity of groundwater extraction wells. During the first week of extraction from each aquifer, water level measurements will be obtained hourly for the first 8 hours of pumping then every 8 hours for the rest of the first day and daily for the next 6 days from the wells and piezometers listed below.

Surficial Aquifer	Lower Patapsco Aquifer
MW-05R	MW-1D
MW-18	MW-16D
MW-38R	MW-22D
MW-42	MW-24D
MW-43	MW-40D
MW-44	MW-41D

Water level measurements will be collected twice per day from the rest of the wells, which represents the second group of monitoring points. The depth to water will be manually measured using an electronic water level indicator. These data, along with measurements from the recovery wells, will be examined to evaluate aquifer hydraulic response during system operation and the significance of any hydraulic head fluctuations. Given the selected pumping rates, it is believed the hydraulic head distribution should begin approaching an initial steady-state condition one to two days after start-up in the Surficial aquifer and less than seven days for the Lower Patapsco aquifer. The water level data will provide an early indication of the response to pumping from the extraction well networks.

During the second week of pumping, synoptic rounds of water level measurements will be collected every two days from all wells then weekly for the next four weeks. Manual depth to water measurements will be made at the monitoring points using an electronic water level indicator. These data will be used to monitor further changes in the hydraulic head distribution in both aquifers under remedial pumping conditions, particularly in areas distant from the extraction points to evaluate containment of the VOC plumes. The actual time for adjusting the measurement frequency from daily to weekly may be modified based on a review of any trends and variability in the water level data.

3.4.1.3 Long-Term Water Level Monitoring

After the start-up period, water levels in the wells in both aquifers will be measured quarterly for the remainder of the first year of pumping. Assuming no unexpected findings or conditions with respect to the hydraulic response within the aquifer system, the water level monitoring frequency will be reduced to semi-annual for the remainder of the systems' operation. The water levels in all monitoring wells and piezometers will be measured by hand using an electronic water level indicator.

During full-scale system operation, the following conditions may warrant more frequent collection of water level data from all or a sub-set of the monitoring wells and piezometers within a particular aquifer (Cohen et al. 1994).

- adjustment in the withdrawal rate from one or more extraction wells
- extraneous factors that may affect flow pathways in the aquifer system

These factors would typically be associated with changes in the magnitude of water sources and sinks to each aquifer, such as significantly increased precipitation recharge (Surficial aquifer) or leakage (Lower Patapsco aquifer) or groundwater pumping from new municipal or commercial/industrial water-supply wells in the area. Any modification in the monitoring frequency will be made on a case-by-case basis in light of the presumed importance of the source/sink on the water balance and flow dynamics.

3.4.2 Groundwater Quality Monitoring

3.4.2.1 Baseline Groundwater Sampling Event

One round of groundwater samples will be collected from the monitoring wells listed in Tables 2 and 3 to characterize the baseline hydrogeochemistry of the Surficial and Lower Patapsco aquifers, respectively. Baseline sampling will be completed less than four weeks before the start of groundwater withdrawals from the aquifer system to gather data on the pre-pumping hydrogeochemical conditions at the site. These data will be evaluated with sampling data obtained during operation of the hydraulic containment systems to evaluate capture of the VOC-impacted groundwater and removal of contaminant mass from the aquifers.

3.4.2.2 Long-Term Groundwater Monitoring

Long-term groundwater quality sampling will be performed to monitor changes in VOC concentrations in the Surficial and Lower Patapsco aquifers during operation of the hydraulic containments system. The proposed sampling frequency for monitoring points in the Surficial and Lower Patapsco aquifers are also provided in Tables 2 and 3, respectively.

For the extraction wells in both containment systems, groundwater samples will initially be collected on a quarterly basis. The monitoring frequency for these wells will be reduced to semi-annual following one year of continuous pumping. The sampling data will be used to monitor changes in VOC concentrations, and corresponding mass removal, in the well discharge.

Groundwater samples collected from the following monitoring wells, which are located in the western portion of the site, will be used to evaluate VOC concentrations in the Surficial aquifer during operation of the hydraulic containment system.

- MW-03
- MW-05R
- MW-18
- MW-38R
- MW-39
- MW-42
- MW-43
- MW-44

Wells MW-05R, MW-18, MW-38R, MW-39, MW-42, and MW-43 will be sampled on a semi-annual basis. The other wells – MW-03 and MW-44 – are located in unaffected portions of the Surficial Aquifer downgradient or cross-gradient of the VOC plume. The groundwater samples will be collected from these wells on an annual basis. The remaining monitoring points for the Surficial aquifer consist of four wells (MW-04, MW-09, MW-16, and MW-20) that occur within the inferred limits of the VOC plume in the area east (hydraulically upgradient) of the extraction well system and new well MW-45 on the Williams-Scotsman property. Semi-annual groundwater samples will be collected from these monitoring wells to evaluate changes in COC concentrations in response to groundwater withdrawals from the extraction wells.

For the Lower Patapsco aquifer, groundwater samples from the monitoring wells listed below will be used to assess VOC concentrations in response to groundwater withdrawals from the deep extraction wells.

- MW-1D
- MW-21D
- MW-22D
- MW-24D
- MW-40D

Samples will be collected from these wells semi-annually. Monitoring wells MW-16D and MW-23D are situated within the VOC plume in the area hydraulically upgradient of the extraction wells. These wells will also be sampled semi-annually to evaluate changes in COC concentrations in response to groundwater pumping. Groundwater samples will be collected on an annual basis from well MW-27D located upgradient of the inferred extent of VOC impacts in the aquifer, and MW-41D, which will be screened at depth below the recovery wells in the lower portion of the aquifer. The collection of samples from “background” well MW-27D will be used to monitor the hydrogeochemistry of groundwater flowing on to the site from off-property areas to the north. Water quality results for MW-41D samples will be evaluated, together with the hydraulic head data, to ensure site-related VOCs are not migrating in deeper portions of the Lower Patapsco aquifer and by-passing the partially penetrating extraction well system.

3.5 Field Methods and Sampling Procedures

3.5.1 Water Level Measurements

Field measurements of the depth to standing water in monitoring wells will be obtained at the frequency described in Section 3.3.1 with an electronic water level indicator. During groundwater sampling events, measurements will be made of the static water and well depth to determine the height of the water column in the well and identify potential siltation problems inside the well casing. All measurements for a given water level monitoring event will be taken within a 10-hour work period to minimize potential discrepancies due to transient head fluctuations. All field measurements will be recorded in a bound field notebook.

3.5.2 Groundwater Sampling and Analysis

3.5.2.1 Recovery Well Sampling Procedure

Groundwater samples will be collected from pumping wells via the sampling port in the well head vault (see Appendix A of the RAP). The valve will be opened to deliver a smooth, thin stream of water, which has a flow low enough to permit filling of the sample bottles without turning the valve down. After purging a small amount of water from the sampling port, a groundwater sample will be collected for laboratory analysis.

3.5.2.2 Monitoring Well Sampling Procedure

Groundwater samples will be collected from the monitoring wells using either the low flow purge and sample method, or a passive sampling method (HydraSleeve). The HydraSleeve is one of several passive sampling technologies demonstrated to be capable of collecting representative groundwater samples for analysis of chlorinated VOCs and 1,4-dioxane (Parker and Clark 2002, Montgomery Watson Harza 2002, Parsons Corporation 2005, and ITRC 2006). Final selection of the sampling method will be based on the results of the field performance study, which will be conducted during the baseline monitoring event.

Information concerning the passive (HydraSleeve) sampling procedure is provided in Section 5.2.2. If the low flow method is selected for collection of the groundwater samples, a description of the field sampling procedure will be provided in a subsequent submittal to MDE. All field information related to the sampling activities will be documented in a bound field notebook.

3.5.2.3 Analytical Methods

The groundwater samples and associated field quality control (QC) samples will be submitted to the Pace Analytical Services, Inc. laboratory in Huntersville, North Carolina (Maryland certification number 322) for chemical analysis. All samples will be analyzed for VOCs using USEPA SW-846 Test Method 8260B and 1,4-dioxane using modified USEPA Method 8260B with selective ion monitoring (SIM). The proposed quantitation limits (QL) for the target compounds listed under USEPA Method 8260B are provided in Appendix A. For 1,4-dioxane analysis using SIM, the reporting limit is 2 µg/l and the method detection limit is 1.9 µg/l.

3.5.3 Field Quality Assurance/Quality Control (QA/QC) Procedures

The field QA/QC procedures to be used for the groundwater monitoring activities will be consistent with the protocols described WSP Field Standard Operating Procedure (SOP) #3 – Sample Packaging and Shipping Procedure, and Field SOP #4 – Sample Collection and Quality Assurance Procedure (Appendix B). These SOPs include standards and guidance for sample identification numbers, sample custody, shipping of samples to the laboratory, and collection of field and QC samples. Additional information concerning on the collection of field QC samples during the monitoring activities is provided in the following sections.

3.5.3.1 Trip Blanks

Trip blanks are samples used to identify possible sample contamination originating from sample transport, shipping, or site conditions. Each trip blank will consist of two or three preserved 40-milliliter glass vials with Teflon®-lined septum caps that are filled with organic-free water. They will be stored with the field samples and returned to the laboratory for VOC analysis. One trip blank will accompany each cooler containing samples to be analyzed for VOCs. Trip blanks will be labeled, documented, and handled in the same manner as other field samples. Trip blanks will be analyzed for VOCs only.

3.5.3.2 Equipment Blanks

If the low flow purge method is used for sample collection, one equipment rinsate blank will be collected each day that sampling activities are conducted at the site. These samples will be used as a QC check of the decontamination procedures for sampling devices. Equipment blanks will be prepared after the equipment has been used and decontaminated in the field. Equipment blanks will be prepared by filling or rinsing the cleaned equipment with analyte-free water and collecting the rinsate in the appropriate sample containers. Equipment blanks will be submitted blind to the laboratory and analyzed for all the analytes for which the environmental samples are being analyzed. Equipment blanks will be labeled, documented, and handled in the same manner as other field samples.

3.5.3.3 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples

An MS/MSD sample will be collected for every 20 samples collected and analyzed as a further QC check. The specific sample location that will be used for the MS/MSD sample will be chosen by WSP field personnel. MS/MSD samples will be labeled and documented as such and handled in the same manner as other field samples. Results from the MS/MSD samples will determine analytical accuracy and precision. The purpose of the spike samples is to monitor any possible matrix effects on specific samples collected from the site.

3.5.3.4 Field Duplicates

Duplicate samples will be collected to allow for determination of analytical precision. One duplicate sample will be collected for every 20 samples from the same matrix and submitted blind to the laboratory for analysis.

3.6 Groundwater Monitoring Optimization

Optimization of the monitoring networks for both the Surficial and Lower Patapsco aquifers will be assessed every 2-3 years to determine whether reductions in sampling frequency and/or changes in the number and locations of monitoring points can be implemented while still assuring attainment of the monitoring objectives. The optimization evaluation will use the Monitoring and Remediation Optimization System (MAROS) software package, developed by Groundwater Services, Inc., to perform qualitative, temporal, and spatial-statistical analyses of the groundwater sampling data from the monitoring wells (USEPA 2004). Parametric and non-parametric methods will be utilized to assess the statistical significance of temporal trends in COC concentrations. The results of the temporal-trend analyses will then be evaluated by the MAROS program to develop recommendations for optimal sampling frequency at each monitoring point using a modified Cost Effective Sampling algorithm. In addition, a spatial statistical algorithm will also be used to assess the relative “value” of the groundwater sampling data being collected from the well network, and identify optimal locations of monitoring points. Formal decision logic may also be used to help evaluate the data and formulate recommendations for modifying the monitoring program.

4 Monitoring Well and Piezometer Abandonment

A total of 20 groundwater wells and piezometers will be abandoned in accordance with the applicable requirements in the following regulations:

- Maryland Code 26 04.04.34 – Well Abandonment and Sealing Standards – General
- Maryland Code 26 04.04.35 – Well Sealing Materials
- Maryland Code 26 04.04.36 – Well Sealing Procedures

As indicated in Figure 6, the majority of the wells designated for abandonment are screened in the unconfined Surficial aquifer. Five wells (MW-2D-138, MW-17D-97, MW-19-56, MW-26D-105, and TW-2-145) are screened in the confined Lower Patapsco aquifer. All well abandonment activities will be conducted by a Maryland-licensed well driller.

The abandonment procedure for the wells and piezometers screened in each hydrogeologic unit are described below.

- Measure the depth to water and total well depth using a water level indicator or weighted tape, and check for the presence of any obstructions inside the well casing. If an obstruction is encountered, WSP will assess the nature and approximate depth of the obstruction and its potential effect on abandoning the well in place.
- Remove the concrete pad and flush-mount or above-grade protective cover and cut the well casing so the top is 0.5-1 foot below grade.
- Backfill the polyvinyl chloride (PVC) well casing with a bentonite-cement grout emplaced from the bottom of the well to the surface using the tremie method.
- After plugging the well, backfill the hole to existing grade with clean soil material obtained from the property.

For wells located in future paved and warehouse areas, the backfilled holes will be covered at the surface with a layer of asphalt patch to match the existing grade. Any wells located in future unpaved (grassy) areas will be seeded following placement of the clean soil fill.

After completing the field activities, a completed Water Well Abandonment Sealing Report will be prepared for each well and submitted to MDE.

5 Monitoring Well Installation

5.1 General

Three new shallow monitoring wells (MW-42, MW-43 and MW-44) and two new deep monitoring wells (MW-40D and MW-41D) will be installed at the former Kop-Flex site as part of the groundwater monitoring network for the groundwater response action. (As previously mentioned, an additional monitoring well [MW-45] will also be installed on the portion of the Williams-Scotsman property to the east of the site; details concerning the installation of this well will be provided in a future submittal to MDE.) The new shallow wells will be installed near the inferred boundaries of the VOC plume in the Surficial aquifer, as shown in Figures 7 and 9, and will be used to obtain groundwater level and quality data to assess the effectiveness of the extraction well system. Well MW-40D will be located near the inferred western boundary of the deeper VOC (Figures 8 and 10), and will be used to gather groundwater level and water quality data to evaluate hydraulic containment of the chlorinated VOCs in the Lower Patapsco aquifer. The other deep monitoring well (MW-41D) will be screened in the lower portion of the aquifer within the plume area to assess vertical head gradients and VOC concentrations in the groundwater system.

In addition, monitoring wells MW-05R and MW-38R will be installed within the upper, predominately fine-grained portion of the Surficial aquifer in the western portion of the site (Figures 7 and 9). These wells will replace existing wells MW-05 and MW-38, which are located in areas of future underground utility lines on the property, and will be used to obtain water level and water quality data to assess the effectiveness of the extraction well system.

All drilling and installation activities will be performed by a driller licensed in Maryland.

5.2 Monitoring Well Installation

5.2.1 Surficial Aquifer Wells

The boreholes for the new monitoring wells will be installed using the roto-sonic drilling method. The MW-05R, MW-38R, and MW-42 borings will be completed to a depth of approximately 25-30 feet bgs, and MW-43 and MW-44 to depths of 35 feet bgs and 40 feet bgs. During borehole advancement, cores of the unconsolidated deposits will be collected and logged in the field. Lithologic descriptions and other pertinent observations will be included in boring logs prepared after completion of the drilling activities.

Based on the site hydrogeologic data, monitoring well MW-42 and the replacement wells will be installed in the predominately fine grained deposits immediately overlying the thick sand unit. Monitoring wells MW-43 and MW-44 will be completed in the upper portion of the predominately sand to clayey sand materials at a slightly greater depth (approximately 40 feet bgs). The actual depths may vary slightly depending upon the lithologic conditions encountered during completion of the respective well boreholes. Each well will be constructed of 2-inch inside diameter (ID), threaded, Schedule 40 polyvinyl chloride (PVC) casing. The screen for well MW-05R, MW-38R, and MW-42 will be 10 feet long and consist of 0.010-inch machined horizontal slots; the MW-43 and MW-44 screens will also be 10 feet in length but with a slot size of 0.020 inches. A filter pack of clean quartz sand appropriate for the designated slot size will be placed down the annular space to a minimum depth of 2 feet above the top of the screen. A 3-foot-thick bentonite seal will be placed above the sand filter pack, and the remainder of the annular space will be filled to approximately 1-foot bgs with a cement-bentonite grout mixture. The piezometers will be completed at grade with a traffic-rated, protective steel cover set in a high strength concrete pad and fitted with a locking, expansion-grip well cap. Well construction information will be recorded in a field notebook, and as-built diagrams included with the boring log.

All drill cuttings and drilling water generated during the installation activities will be contained in Department of Transportation (DOT)-compliant 55-gallon steel drums. The drums will be labeled and moved to a staging area on the property at the end of each work day for subsequent management and disposal.

The newly installed monitoring wells will be developed by extracting groundwater from the casing using a suitable pump. All water will be contained in DOT-compliant 55-gallon steel drums. Turbidity, pH, temperature and specific conductivity will be periodically monitored during the development process to ensure that water representative of the screened potion of the aquifer is entering the piezometer. Development will continue until the discharge is relatively free of fine suspended sediments.

5.2.2 Lower Patapsco Aquifer Monitoring Wells

Two deep, double-cased monitoring wells (MW-40D and MW-41D) will be installed in the Lower Patapsco aquifer to gather hydrologic and hydrogeochemical data for assessing the performance of the hydraulic containment system. The borehole for well MW-40D will be installed to an approximate depth of 115 feet bgs using the roto-sonic drilling method. The well MW-41D borehole will be completed to approximately 165 feet bgs using the same drilling method. The proposed borehole depths are based on the recovery well construction details and groundwater quality data obtained from other deep monitoring wells in this portion of the site.

A continuous core of the unconsolidated Coastal Plain deposits will be collected from the ground surface to borehole termination depth, and logged in the field by the WSP site geologist. Lithologic descriptions and other pertinent observations will be included in a boring log prepared after completion of the drilling activities. Upon encountering the confining unit at an approximate depth of 60 feet bgs, a 7-inch diameter outer steel casing will be advanced a few feet into the clayey layer and sealed in place using a cement-bentonite grout mixture. The actual depth for setting of the outer steel casing will be dependent on the lithology encountered during the drilling activities. After allowing sufficient time for setting of the grout seal, the borehole will be advanced through the confining layer and into the underlying confined Lower Patapsco Aquifer. In this aquifer unit, depth-discrete groundwater samples will be collected at approximately 10-foot intervals over the depth of approximately 90 feet to 150 feet bgs. Each sample will be obtained after purging sufficient water from the sampling tool to ensure the collection of groundwater representative of the aquifer. Grab water samples will be collected for both field screening for 1,1-DCE using a colorimetric tube procedure and submittal to a local analytical laboratory – Phase Separation Sciences in Baltimore, Maryland – for VOC analysis. A maximum of three groundwater samples will be collected from the MW-40D well borehole and five samples from the MW-41D borehole.

Each monitoring well will be constructed of 2.5-inch ID, threaded, Schedule 80 PVC casing with a 10-foot long screen consisting of 0.020-inch machined horizontal slots. A filter pack of clean quartz sand appropriate for the designated slot size will be placed down the annular space to a minimum depth of 2 feet above the top of the screen. A 3-foot-thick bentonite seal will be placed above the sand filter pack, and the remainder of the annular space will be filled to approximately 1-foot bgs with a cement-bentonite grout mixture. The well will be completed at grade with a traffic-rated, protective steel cover set in a high strength concrete pad and fitted with a locking, expansion-grip well cap. Well construction information will be recorded in a field notebook, and an as-built diagram included with the boring log. A construction schematic for this double-cased monitoring well is provided in Figure 11.

All drill cuttings and drilling water generated during the installation activities will be contained in DOT-compliant 55-gallon steel drums. The drums will be labeled and moved to a staging area on the property at the end of each work day for subsequent management and disposal.

The newly installed wells will be developed by extracting groundwater from the casing using a suitably-sized submersible pump. All well discharge will be contained in DOT-compliant 55-gallon drums. Turbidity, pH, temperature and specific conductivity will be periodically monitored during the development process to ensure that water representative of the aquifer is entering the well screen. Development will continue until the discharge is relatively free of fine suspended sediments.

5.3 Surveying

After completing the installation activities, the location and elevation of the ground surface and measuring point at the top of the PVC casing will be determined for the new monitoring wells. The location coordinates and elevations will be determined by a surveyor licensed in the state of Maryland, and will be consistent with standard technical practices. All horizontal locations will reference the North American Datum of 1983 for reference; vertical elevations will be referenced to the North American Vertical Datum of 1998.

5.4 Management of Investigation-Derived Media

Investigation-derived media (IDM) generated during the installation of the monitoring wells for the proposed response action monitoring activities will include the following:

- drill cuttings
- solid-containing drilling water
- purge water from depth-discrete groundwater sampling
- groundwater from well development
- miscellaneous solid materials that come in contact with potentially contaminated soil or groundwater (e.g., personal protective equipment, plastic, tubing, etc.)

As discussed in Section 5.2 above, all IDM will be containerized in DOT-compliant, open or closed-top, 55-gallon steel drums. These materials will be segregated into two groups, with one consisting of potentially VOC-contaminated material and the other comprising potentially non-impacted media. All drummed materials will be moved to a covered and paved staging area at the site and labeled as “non-hazardous pending analysis”.

Composite samples will be collected of the drill cuttings and drilling water from the well installation activities, and analyzed for the applicable analytical parameters to determine the appropriate management of these materials. In addition, samples of the development water from both shallow and deep wells will be collected for waste characterization analysis. Laboratory analytical results for the groundwater samples will be used to characterize the sample purge water from the MW-40D and MW-41D boreholes. Characterization of the miscellaneous solid materials will be consistent with the associated environmental media. All IDM will be managed in accordance with applicable state and federal regulations.

6 Passive Sampler Field Demonstration Study

6.1 Study Approach

Previous groundwater monitoring events at the former Kop-Flex site have utilized standard purge or low flow purging methods to collect samples for VOC analysis. Over the past decade, a significant research effort has been focused on understanding the applicability and use of passive, or no-purge, sampling technologies for the collection of groundwater quality samples from monitoring wells. These sampling methods include the HydraSleeve sampler, which is a grab-sampling device that collects an "instantaneous" groundwater sample without the purging or mixing of liquid within the water column of the well. Salient technical findings concerning the potential applicability of HydraSleeve samplers for the collection of groundwater quality data at the Kop-Flex site include the following (ITRC 2007).

- Capability of obtaining groundwater samples for most chemical parameters because method involves the collection of a time-specific grab sample and is not reliant on diffusive processes in the well.
- Sampler is easy to deploy and recover, and is disposable, thereby eliminating the need for the field decontamination of sampling equipment and collection of regular equipment rinsate blanks.
- Ability to obtain representative groundwater samples from both low and high yield monitoring wells.
- Sample collection method results in the minimal displacement of water inside the well casing.

Since the research findings support the use of HydraSleeve samplers for the COCs and hydrogeologic conditions at the former Kop-Flex site, WSP recommends the use of this sampling technology for the long-term groundwater monitoring activities. A field demonstration test will be conducted to confirm the applicability of the HydraSleeve sampler in obtaining representative groundwater samples from the Surficial and Lower Patapsco aquifers. The field test will be completed approximately two months before the baseline groundwater sampling event to allow sufficient time for finalizing the sample collection procedure and obtaining regulatory approval.

Since the initiation of groundwater remedial actions in 2002-2003, semi-annual monitoring has been implemented to assess groundwater quality at the site. Over the past four years, additional surficial and deep aquifer wells have been incorporated into the site monitoring program. With the completion of the 2014 monitoring activities, the number of sampling events will be greater than 20 for Surficial Aquifer wells, and between 6 and 10 for the majority of the wells in the Lower Patapsco Aquifer.

A review of the historical sampling data for both the Surficial and Lower Patapsco aquifer through 2013 shows minor temporal variability in COC concentrations in the affected portion of the aquifer. (The 2014 sampling results are excluded because of possible transient effects on VOC mass distribution resulting from the April-May aquifer test activities.) As shown in Figures 12 and 13, these variations are most prevalent in the upper-most hydrogeologic unit, which probably reflect the influence by changes in precipitation recharge and associated groundwater surface fluctuations, and the status of active remedial measures in different portions of the site. Given the ongoing monitoring activities, sufficient groundwater sampling data is available to characterize the hydrogeochemical conditions in the VOC-affected portions of the aquifer system. Therefore, the sampler demonstration test will involve the comparison of groundwater quality data obtained using the HydraSleeve sampler with the historical monitoring results.

6.2 HydraSleeve Field Demonstration Test

6.2.1 Sampling Locations

The HydraSleeve sampler will be deployed in 6 of the 12 monitoring wells in the groundwater quality monitoring network for the Surficial aquifer, and 5 of the 9 wells in the Lower Patapsco aquifer monitoring network. The selected monitoring points are listed below and identified in Figures 14 and 15.

Surficial Aquifer	Lower Patapsco Aquifer
MW-03	MW-1D
MW-04	MW-16D
MW-05R	MW-21D
MW-09	MW-23D
MW-16	MW-24D
MW-18	

Sampling locations for the field demonstration test were selected to include wells that were (1) screened in relatively low and high permeability aquifer materials and (2) will have data for a minimum of six monitoring events by June 2015. For the Surficial aquifer, four of the proposed HydraSleeve sampler test locations (MW-04, MW-05R, MW09, and MW-16) are located within the inferred limits of the VOC plume, with the two remaining wells (MW-03 and MW-18) situated hydraulically downgradient of the area of VOC affected groundwater. All of the Lower Patapsco aquifer wells selected for the test are situated within the known VOC plume area.

6.2.2 Sampling Activities

6.2.2.1 General

The approach for the HydraSleeve field demonstration test will involve sampler deployment in the selected monitoring wells in both aquifers at the same time. WSP will set all of the passive samplers over a one to two-day field period. Given the range in permeability of the aquifer materials screened by the test wells, the samplers will remain in place for a minimum of two weeks to allow for the re-stabilization of analyte concentrations in the wells. After reaching the equilibration period, the HydraSleeve samplers will be removed from the selected monitoring points and samples collected for laboratory analysis.

The following section provides a description of the procedure for obtaining the groundwater samples using this passive sampling technology. Detailed information on the deployment and sample collection and recovery using the HydraSleeve is included in Appendix C.

6.2.2.2 HydraSleeve Sampling Procedure

Initially, the depth to water and total depth will be measured for the selected wells prior to deployment of the HydraSeleeve samplers. These field measurements will be reviewed, along with the well construction information, to determine the target depths for placing the passive samplers.

Construction details and lithologic descriptions of the aquifer materials within the screen intervals were reviewed for the monitoring wells selected for deployment of the passive samplers. Based on this information, a single HydraSleeve sampler will be placed down all of the wells to collect groundwater samples for the field demonstration test. Single HydraSleeve samplers will be set so as to target sample collection over the 2.5 to 5-foot portion of the screen in communication with the more permeable (i.e., coarser) aquifer materials. The proposed depth intervals for setting the samplers in the test wells are provided in Table 4.The 2.5-foot long HydraSleeve sampler will be attached to a weighted, nylon suspension tether and set at the pre-determined depth within the screen interval. The placement of the HydraSleeve will involve first lowering the sampler to the bottom of the well and very slowly raising the sampler so the valve/opening is at the prescribed depth – termed "bottom-up deployment". The suspension line will then be secured at the well head to ensure the sampler remains at the designated depth during the two-week re-stabilization period. Following equilibration, the groundwater sample will be collected by continuously pulling upward on the HydraSleeve until full. The HydraSleeve will be carefully removed from the well, and the sample immediately collected in the appropriate containers to minimize the diffusive loss of VOCs through the polyethylene wall of the sampler. After obtaining the requisite sample volume from the HydraSleeve for chemical analysis, a representative aliquot of the remaining water will be placed into the sample cup of a suitable multi-parameter field meter for measurement of the following hydrogeochemical parameters:

- temperature
- pH
- specific conductivity

The field parameter measurements for each sample will be documented in a bound field notebook. The procedures for sample labeling, custody and shipping will follow the requirements specified in the WSPs Field SOPs (Appendix B). The groundwater samples will be analyzed for VOCs using USEPA SW-846 Test Method 8260B and 1,4-dioxane using modified USEPA Method 8260B with SIM.

6.2.3 Field QC Sample Collection

In addition to a trip blank, the QC samples for assessing the data quality during the HydraSleeve field demonstration test will consist of a field duplicate and equipment blank. The equipment blank will be used as a control sample and to identify potential biases for any target compounds. This sample will be collected by filling one, un-used sampler with deionized or distilled water, and then transferring water to the necessary sample containers in the same manner as a groundwater sample.

6.3 Data Evaluation and Sampling Method Recommendation

The data evaluation will utilize both qualitative and quantitative assessment of the comparability of the groundwater quality data obtained using the passive sampling method and conventional (standard and low-flow purging) methods. Quantitative evaluation of the demonstration test data will primarily involve the analysis of well-specific data plots and comparing the HydraSleeve sampler data with historical results. Statistical values (e.g., mean, standard deviation, median, etc.) may be calculated for the historical sampling data to assist in characterizing VOC concentrations at a given monitoring point. The passive sampler data will be reviewed in light of the "logical filters" outlined in Parson (2005) before conducting the comparison evaluation. These filters will concern the potential exclusion of data points based on the presence of non-detected values for site-related COCs and the quality of the reported laboratory results after completing a data quality assurance review.

The evaluation of the field demonstration test results will be used to conclude whether the HydraSleeve sampler provides groundwater samples representative of hydrogeochemical conditions in the aquifer at the proposed monitoring points. It should be noted that differences in VOC concentrations between the passive sampling method and historical samples collected using conventional methods may not necessarily indicate the HydraSleeve sampler does not adequately monitor the ambient groundwater quality. The low-flow sampling method will be the default sampling technology in the event the HydraSleeve sampler is deemed inappropriate for the long-term monitoring program. A summary of the field demonstration test results and sampling method recommendation will be forwarded to MDE for review and approval before conducting the base line groundwater monitoring event.

If the HydraSleeve is deemed a suitable sample collection method, one sampler will be used in all wells during future groundwater sampling events. For these monitoring points, the HydraSleeve sampler will be placed at the approximate mid-point of the screen interval.

7 Evaluation and Reporting of Monitoring Data

7.1 Data Tabulation

The analytical results for each groundwater sample collected during a particular monitoring event will be presented in tabular format, along with the sampling date and any associated data qualifiers. Non-detect results will be represented using the quantitation limit for the compound and the “U” data qualifier. Additionally, historical data tables, which include COC concentrations for all or selected monitoring points, will be prepared and updated in conjunction with the preparation of the data tables.

7.2 Data Evaluation

A systematic analysis of the hydraulic capture and containment of the VOC plume will be conducted using both the water level and groundwater quality data. The overall groundwater capture evaluation will be similar to the process described in the U.S. EPA guidance document *A Systematic Approach for the Evaluation of Capture Zones at Pump and Treat Systems* (USEPA 2008). This evaluation approach will include preparing groundwater surface and drawdown contour maps and well pair hydrographs to determine horizontal and vertical gradients, and concentration versus time plots for wells located cross-gradient and downgradient of the extraction well systems. The groundwater surface contours will be compared to predicted values from the remedial pumping flow simulations to assess the accuracy of the analytical model results.

The groundwater monitoring results will also be evaluated to assess the performance of the remedial system with respect to the removal of mass from the impacted aquifers. Data analysis will include the preparation of temporal concentration plots for wells situated within the pre-remediation plume boundaries at the site. Statistical methods, such as non-parametric trend analysis (Mann-Kendall and Mann-Whitney tests), may be used to assess the significance of temporal trends in the COC concentrations in groundwater.

7.3 Reporting of Monitoring Data

The water level data and groundwater sampling results will be included as part of the Operation, Maintenance and Monitoring (OM&M) reports for the hydraulic containment systems. As discussed in Section 14.2 of the RAP, quarterly reports will be submitted to MDE containing the water level and groundwater sampling data obtained during the first year of system operation. After the first year of continuous groundwater pumping, this information will be provided on an annual basis. The information provided in the OM&M reports will include a discussion of the monitoring activities, event-specific and historical data tables, and interpretation of the water level and groundwater quality data in terms of the groundwater remedial objectives and cleanup criteria. The OM&M reports will also include electronic copies of the certified laboratory analytical reports for all groundwater sampling events conducted during the reporting period.

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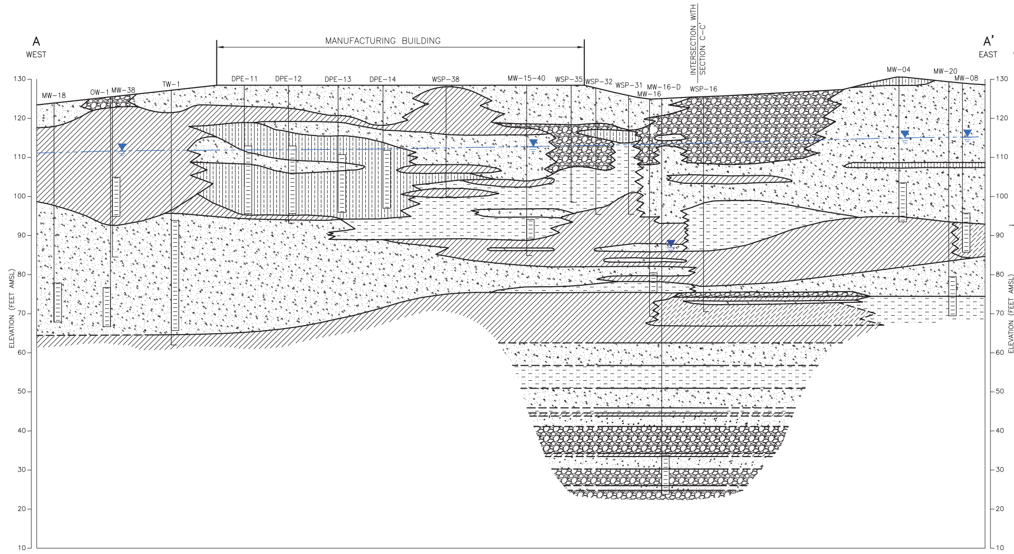
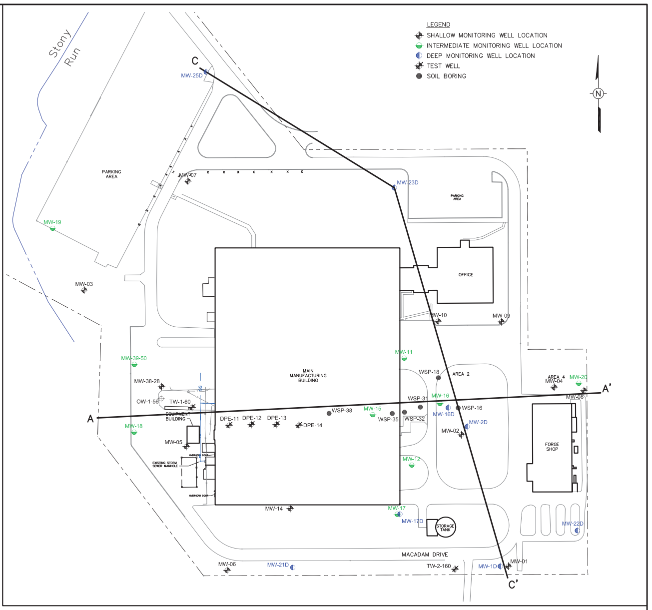
9 Acronyms

bgs	below ground surface
COCs	chemicals of concern
DCA	1,1-dichloroethane
DCE	1,1-dichloroethene
DOT	Department of Transportation
GWMP	Groundwater Monitoring Plan
H&S	health and safety
HASP	Health and Safety Plan
ID	inside diameter
IDM	Investigation-derived media
MAROS	Monitoring and Remediation Optimization System
MCLs	maximum contaminant levels
MDE	Maryland Department of the Environment
msl	mean sea level
OM&M	Operation, Maintenance and Monitoring
PCE	tetrachloroethene
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QL	quantitation limits
RAP	Groundwater Response Action Plan
SIM	selective ion monitoring
SOP	Standard Operating Procedure
TCA	1,1,1-trichloroethane
TCE	trichloroethene
USEPA	U.S. Environmental Protection Agency
VCP	Voluntary Cleanup Program
VOCs	volatile organic compounds

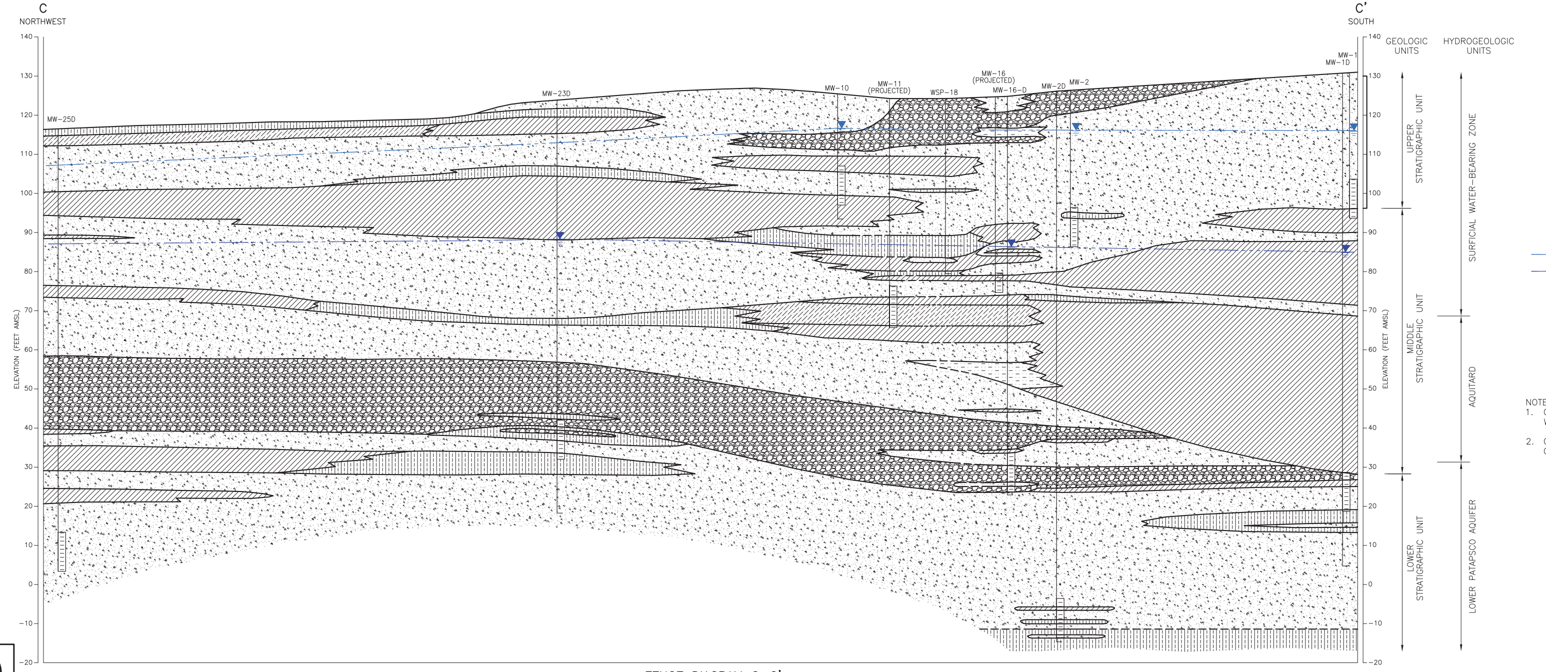
Figures



FENCE DIAGRAM A-A'



FENCE DIAGRAM LOCATIONS
SCALE: 1"=120'

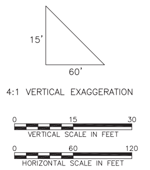


FENCE DIAGRAM C-C'

LEGEND

- ▩ GRAVELLY SAND
- ▨ SAND - SILTY SAND - CLAYEY SAND
- ▤ INTERLAYERED SAND AND CLAY
- ▥ CLAYEY TO SANDY SILT
- ▧ SANDY TO GRAVELLY CLAY
- ▨ SILTY CLAY TO CLAY
- BOREHOLE
- SCREEN
- BOTTOM OF BOREHOLE
- ▼ WATER LEVEL IN SHALLOW MONITORING WELL
- ▼ WATER LEVEL IN DEEP MONITORING WELL
- — — SHALLOW ZONE GROUNDWATER SURFACE ELEVATION
- — — POTENTIOMETRIC SURFACE FOR DEEP GROUNDWATER ZONE

NOTES:
1. GROUNDWATER ELEVATIONS FOR SHALLOW AND INTERMEDIATE WELLS FROM DATA COLLECTED IN JULY 2013.
2. GROUNDWATER ELEVATIONS FOR DEEP WELLS FROM DATA COLLECTED IN SEPTEMBER 2013.



4:1 VERTICAL EXAGGERATION

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D

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REV	DESCRIPTION		
1	Revised:	Chkd:	Appr.:
2	Revised:	Chkd:	Appr.:
3	Revised:	Chkd:	Appr.:

SEAL

DATE

DRAWN BY	EGC	
CHECKED	MCR	10/10/14
APPROVED		

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HYDROGEOLOGIC FENCE DIAGRAMS

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HANOVER, MARYLAND
PREPARED FOR
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FIGURE 1

Drawing Number
00003705-180

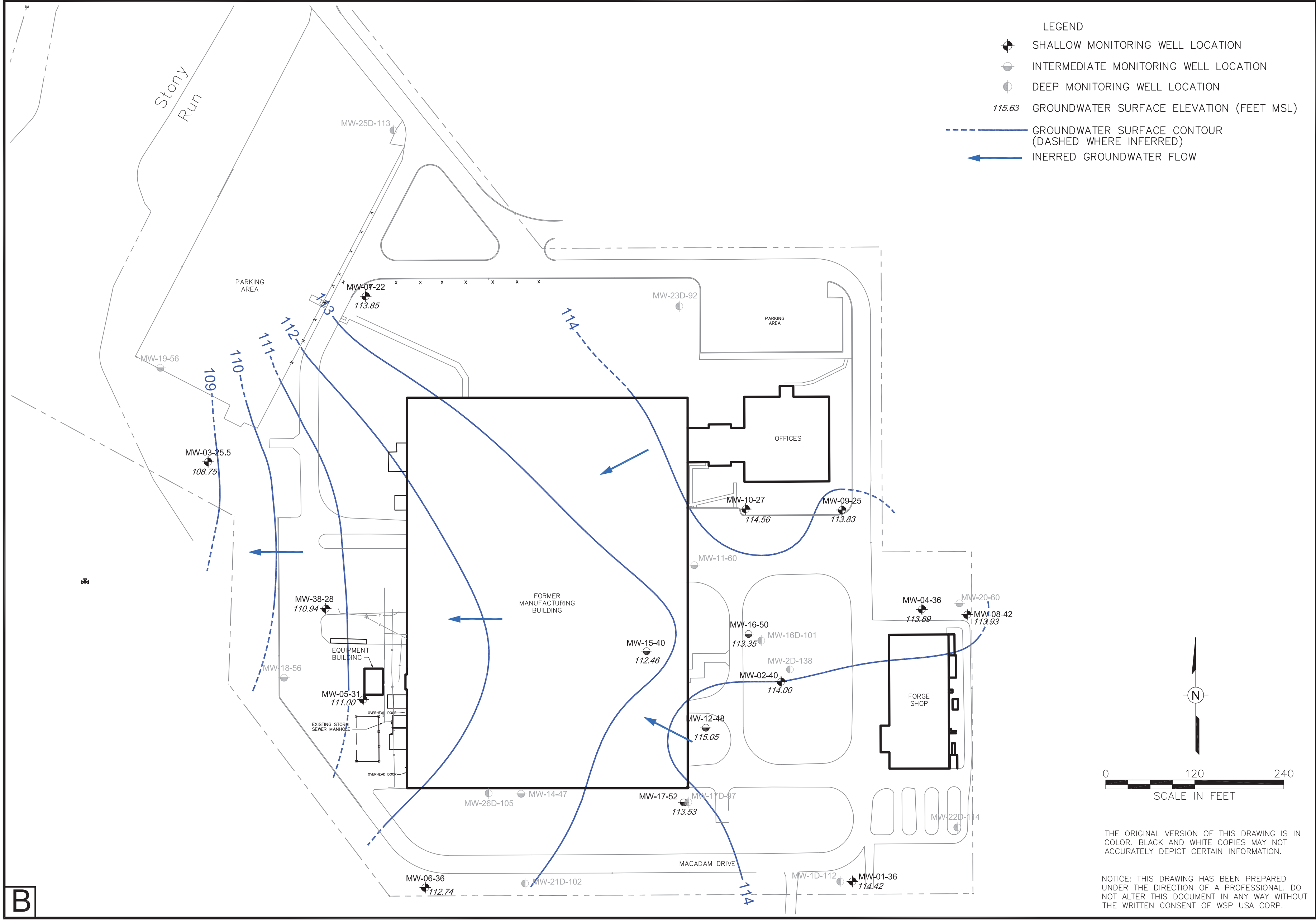

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Figure 2

GROUNDWATER SURFACE CONTOUR MAP
SURFICIAL AQUIFER
DECEMBER 2014

FORMER KOPFLEX FACILITY
HANOVER, MARYLAND
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EMERSON
ST. LOUIS, MISSOURI

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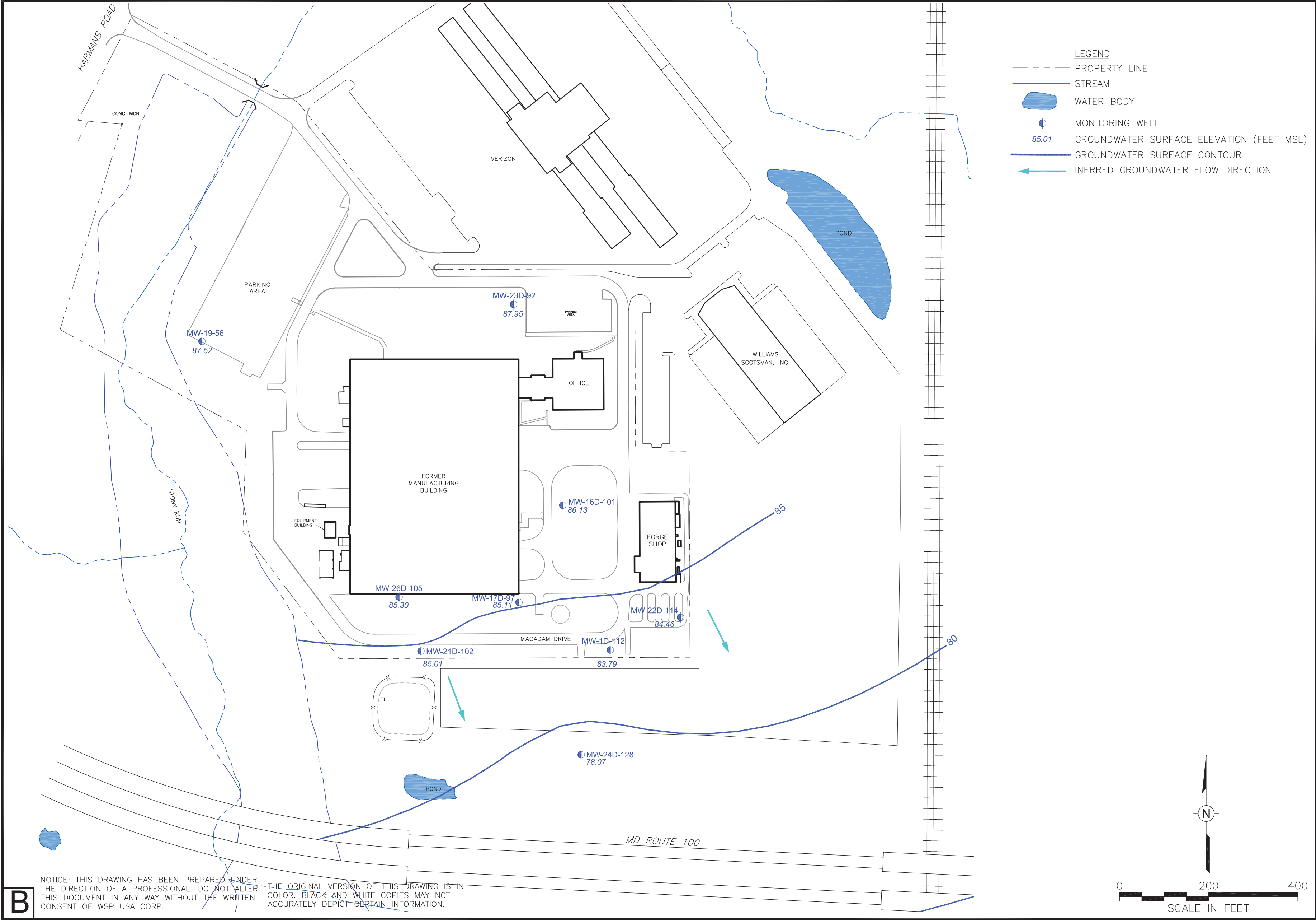

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FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Figure 3

POTENTIOMETRIC CONTOUR SURFACE MAP
LOWER PATAPSCO AQUIFER
DECEMBER 2014

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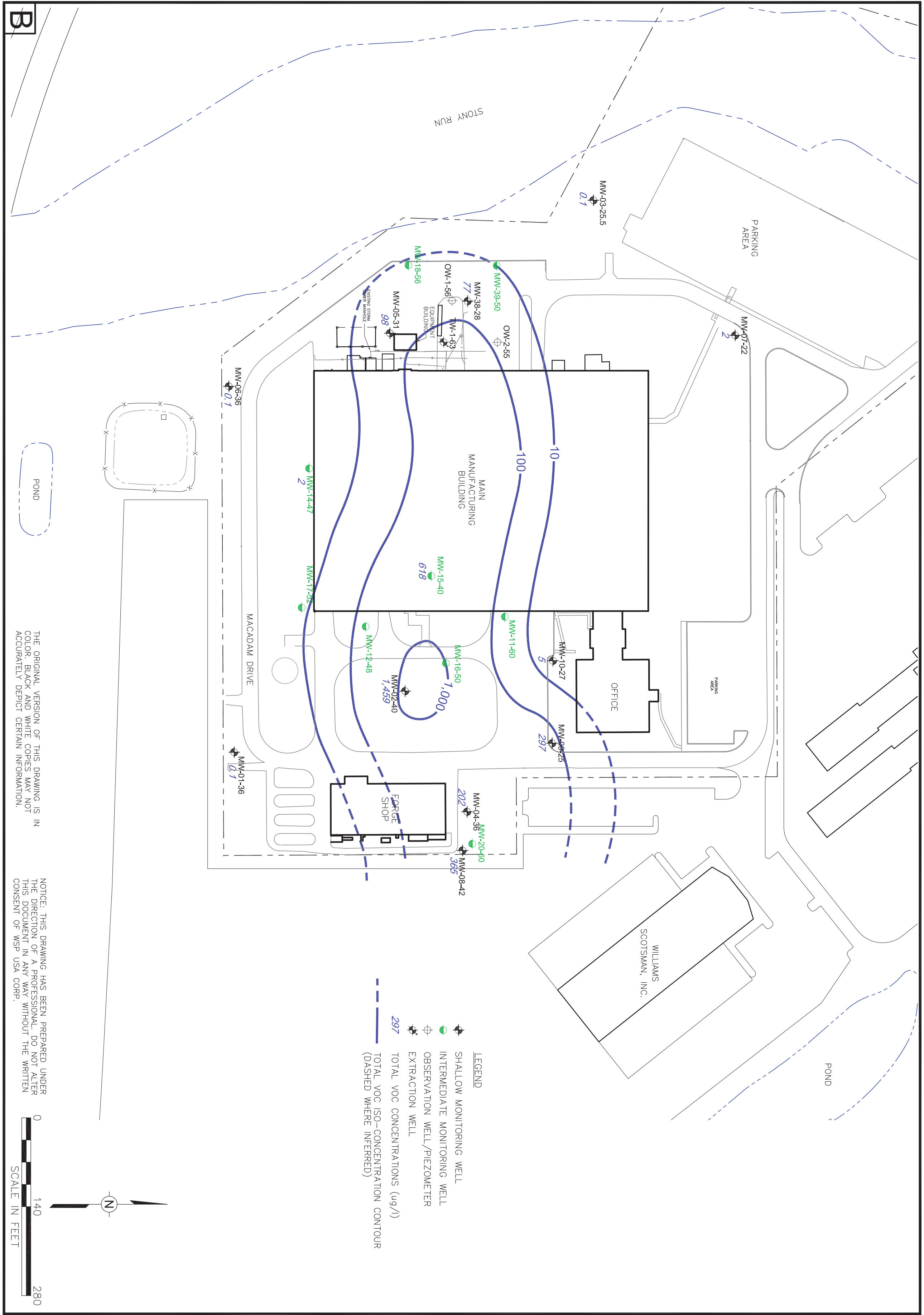

LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- OBSERVATION WELL/PIEZOMETER
- EXTRACTION WELL
- 297 TOTAL VOC CONCENTRATIONS (ug/l)
- TOTAL VOC ISO-CONCENTRATION CONTOUR (DASHED WHERE INFERRED)

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Figure 4

CURRENT SITE LAYOUT WITH TOTAL VOC CONCENTRATIONS IN SHALLOW GROUNDWATER (DECEMBER 2014)

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
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EMERSON
ST. LOUIS, MISSOURI

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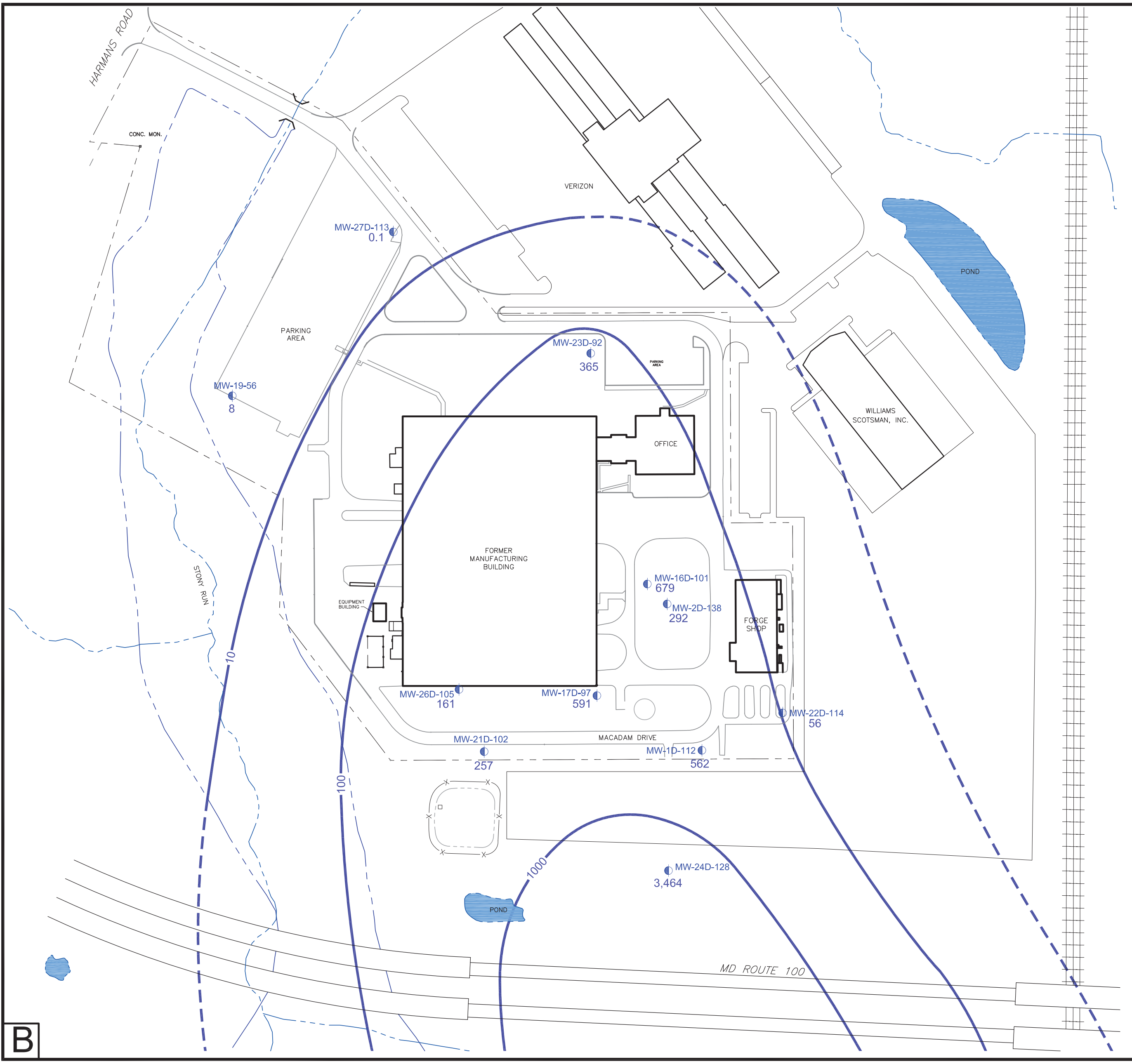

LEGEND

— - — PROPERTY LINE

- - - STREAM

WATER BODY

◐ DEEP MONITORING WELL

— — TOTAL VOC ISO-CONCENTRATION CONTOUR (ug/l) (DASHED WHERE INFERRED)

365 TOTAL VOC CONCENTRATION (ug/l)

N

0 200 400
SCALE IN FEET

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Figure 5

CURRENT SITE LAYOUT WITH TOTAL VOC
CONCENTRATIONS IN LOWER PATAPSCO AQUIFER
(DECEMBER 2014)

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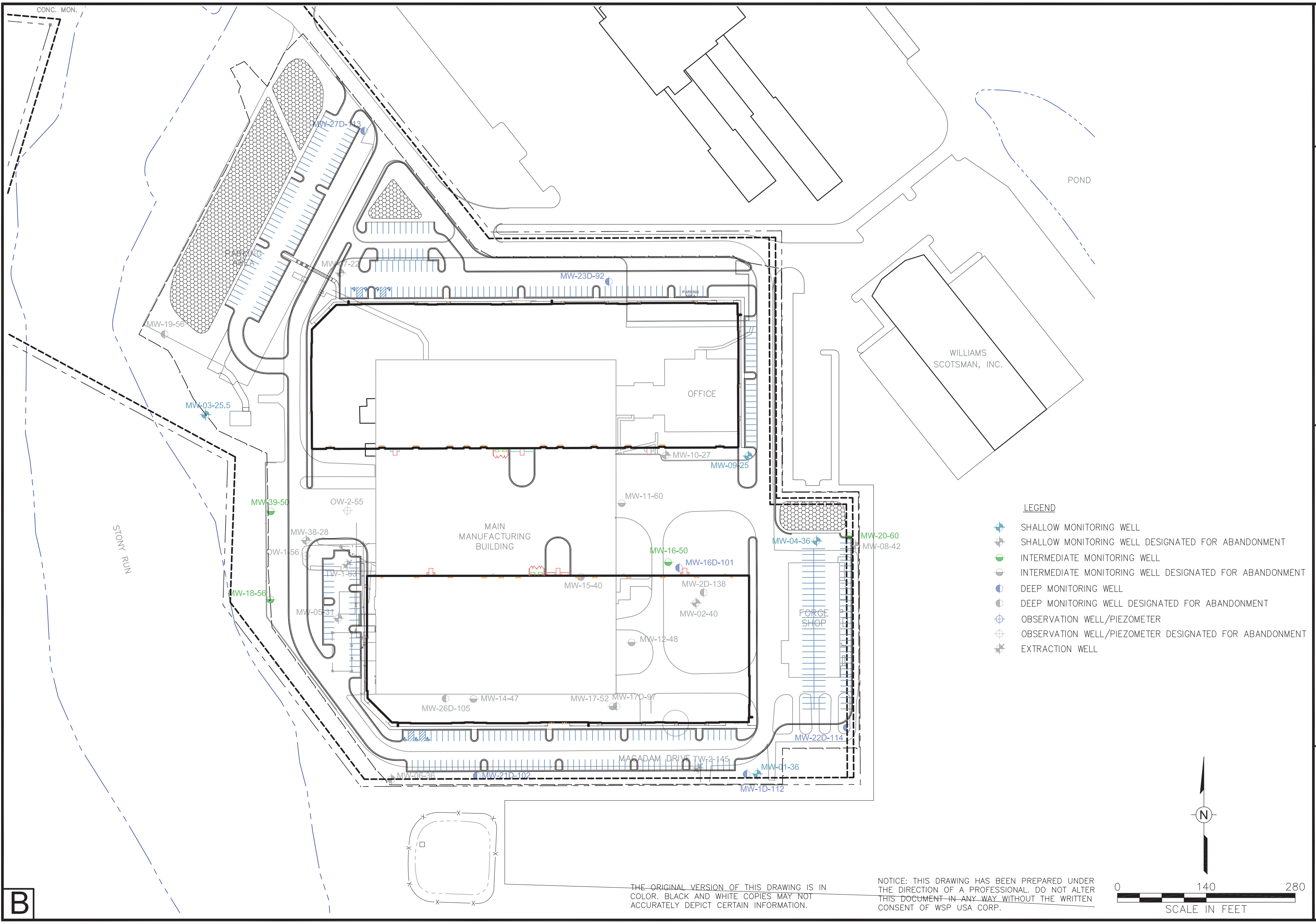

LEGEND

- SHALLOW MONITORING WELL
- SHALLOW MONITORING WELL DESIGNATED FOR ABANDONMENT
- INTERMEDIATE MONITORING WELL
- INTERMEDIATE MONITORING WELL DESIGNATED FOR ABANDONMENT
- DEEP MONITORING WELL
- DEEP MONITORING WELL DESIGNATED FOR ABANDONMENT
- OBSERVATION WELL/PIEZOMETER
- OBSERVATION WELL/PIEZOMETER DESIGNATED FOR ABANDONMENT
- EXTRACTION WELL

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Figure 6

EXISTING WELLS PLANNED
FOR ABANDONMENT

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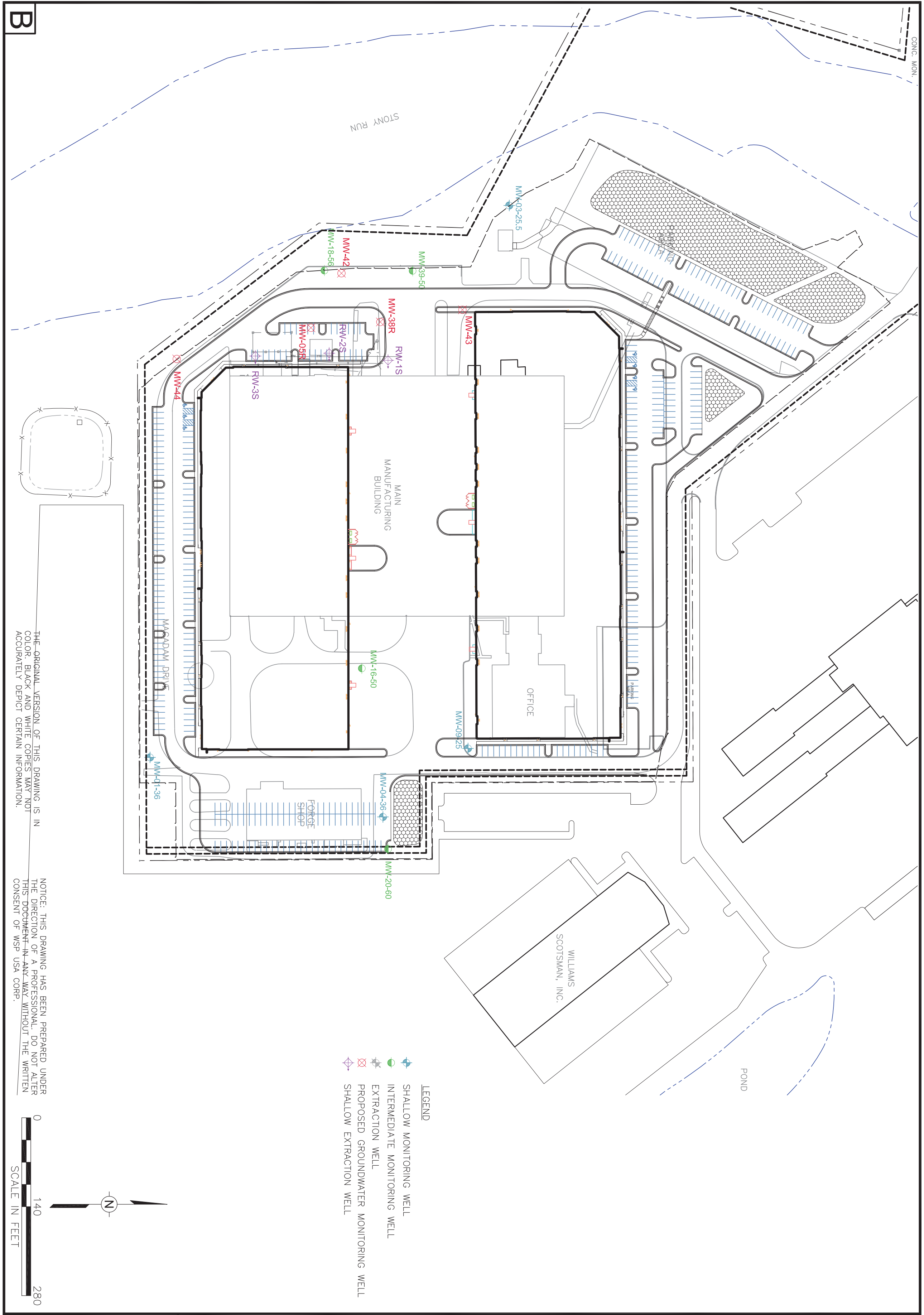

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Figure 7

CURRENT AND FUTURE SITE LAYOUT
WITH SURFICIAL AQUIFER WELLS
FOR COLLECTION OF WATER LEVEL DATA

FORMER KOPFLEX FACILITY
HANOVER, MARYLAND

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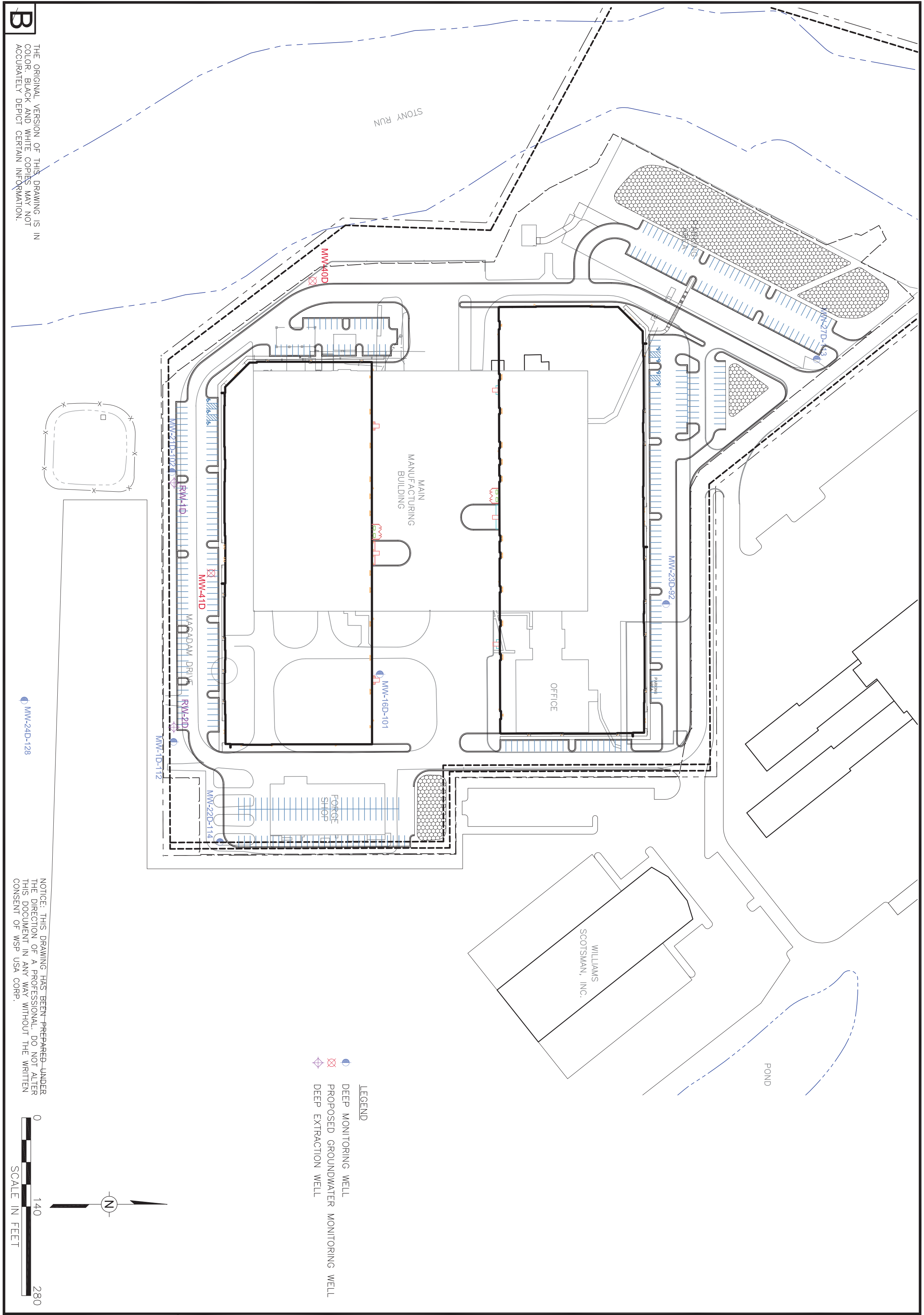

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Figure 8

CURRENT AND FUTURE SITE LAYOUT WITH LOWER PATAPSCO AQUIFER WELLS FOR COLLECTION OF WATER LEVEL DATA

FORMER KOPFLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: RJD 5/29/2015
DWG Name: 00003705–216

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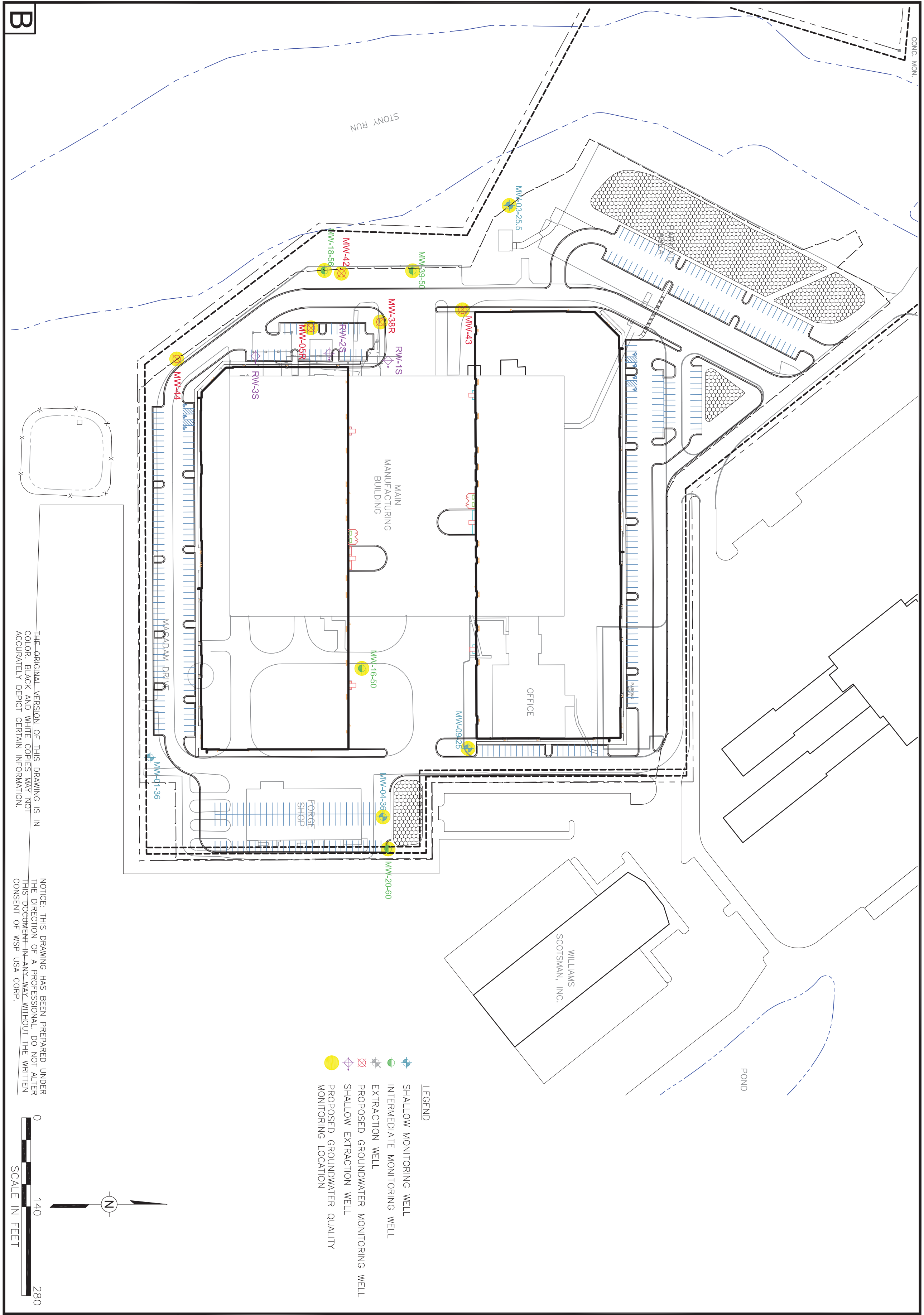

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Figure 9

SURFICIAL AQUIFER GROUNDWATER QUALITY MONITORING POINTS

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
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Approved: RLD 5/29/2015
DWG Name: 00003705-215

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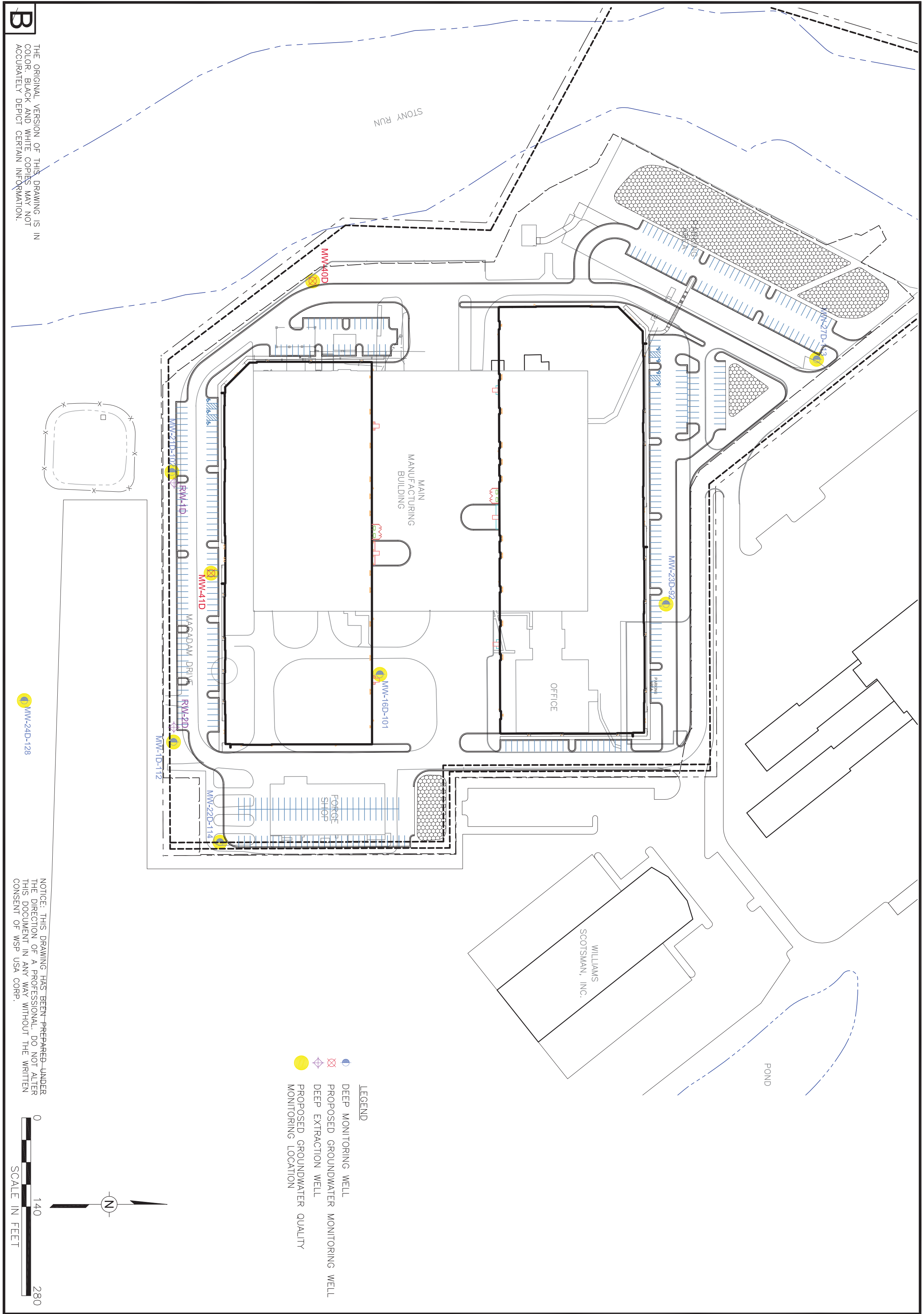

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Figure 10

LOWER PATAPSCO
GROUNDWATER QUALITY MONITORING POINTS

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

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DWG Name: 00003705-187

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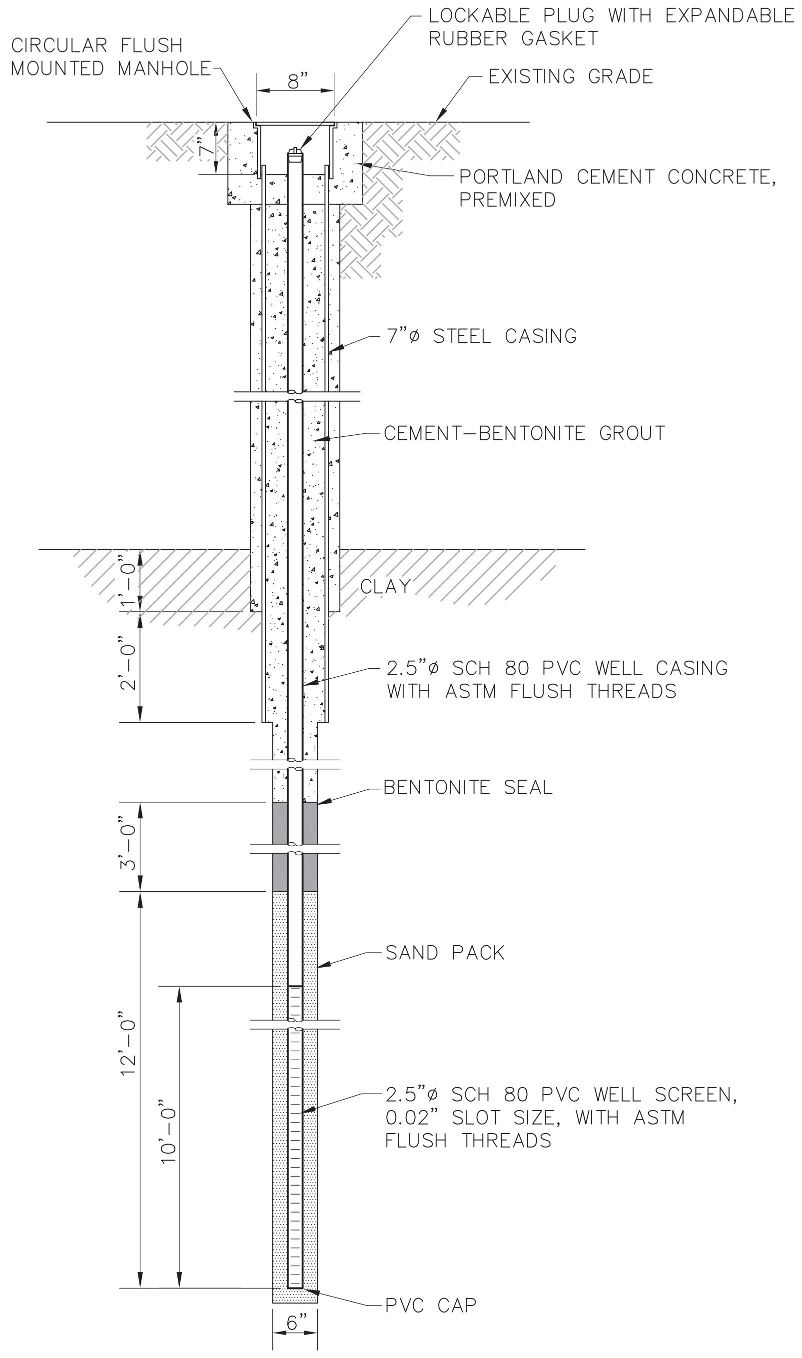

NOTE: PROPOSED WELL WILL BE INSTALLED USING THE ROTO–SONIC DRILLING METHOD.

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Figure 11

CONSTRUCTION FOR PROPOSED DEEP MONITORING WELLS

FORMER KOPFLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON

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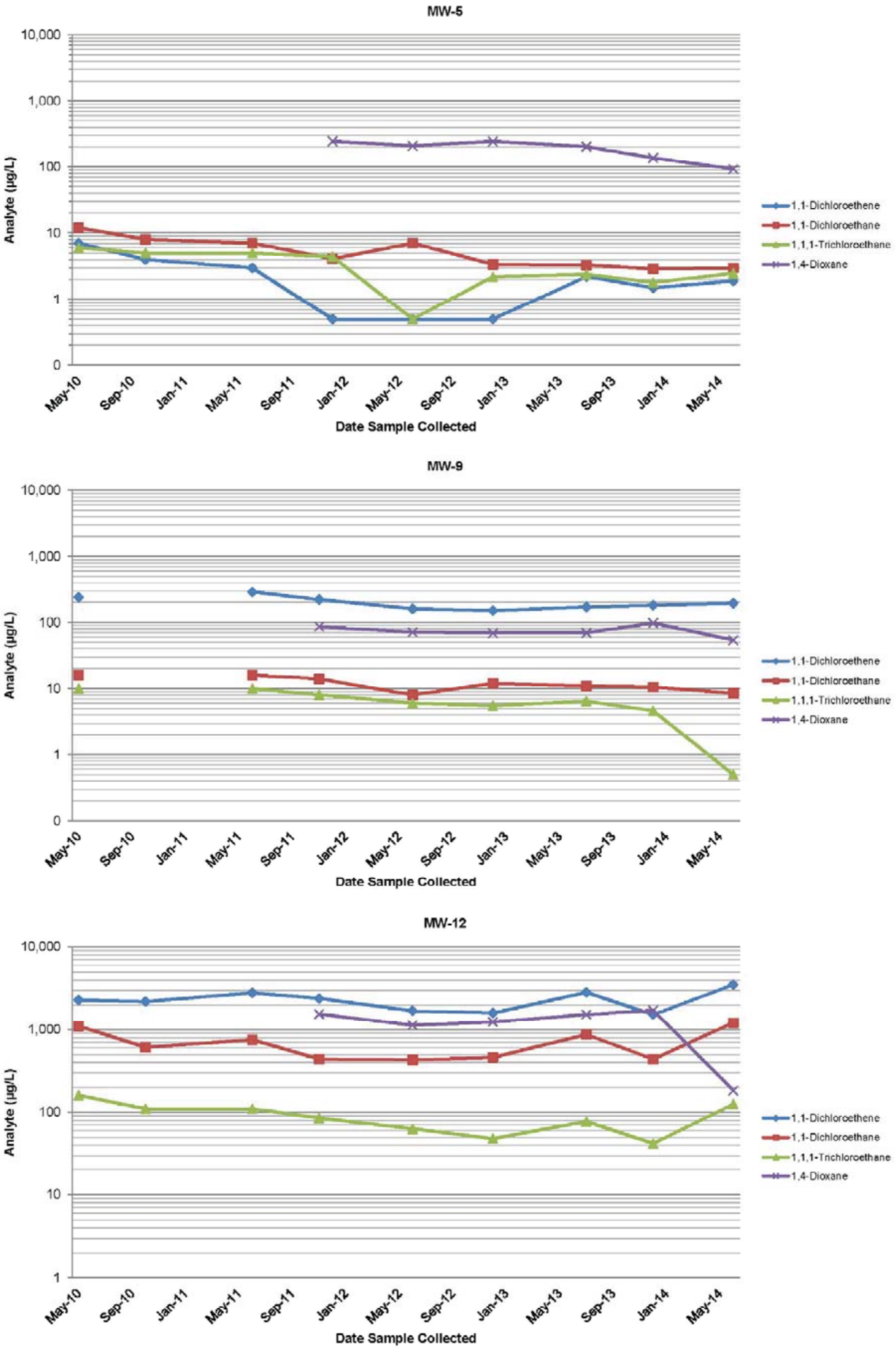

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Figure 12

CONCENTRATIONS OF SITE–RELATED COCs IN SURFICIAL AQUIFER GROUNDWATER SAMPLES (2010–2014)

FORMER KOPFLEX FACILITY
HANOVER, MARYLAND

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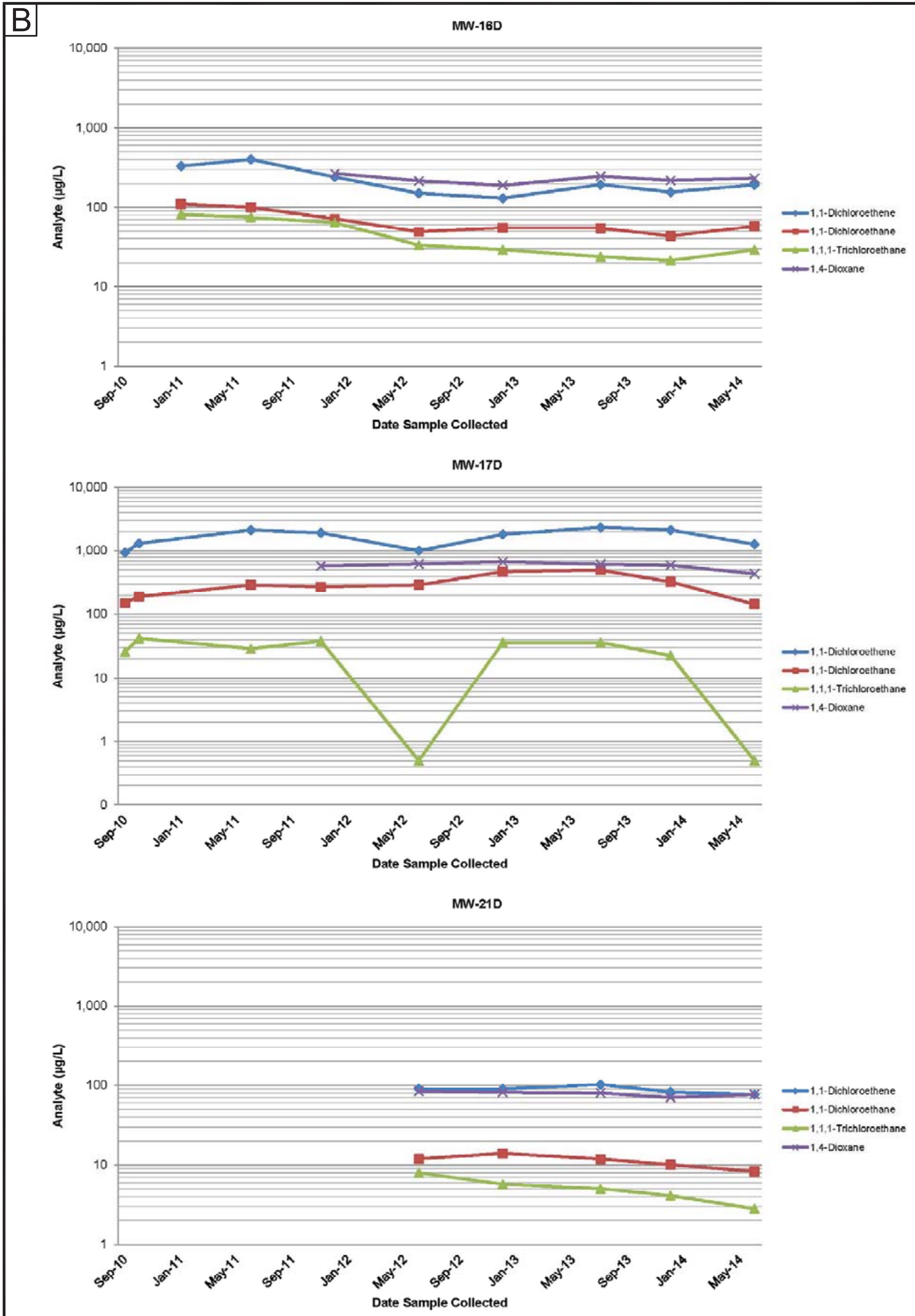

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Figure 13

CONCENTRATIONS OF SITE-RELATED COCs IN LOWER PATAPSCO AQUIFER GROUNDWATER SAMPLES (2010–2014)

FORMER KOPFLEX FACILITY
HANOVER, MARYLAND

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Drawn By: EGC
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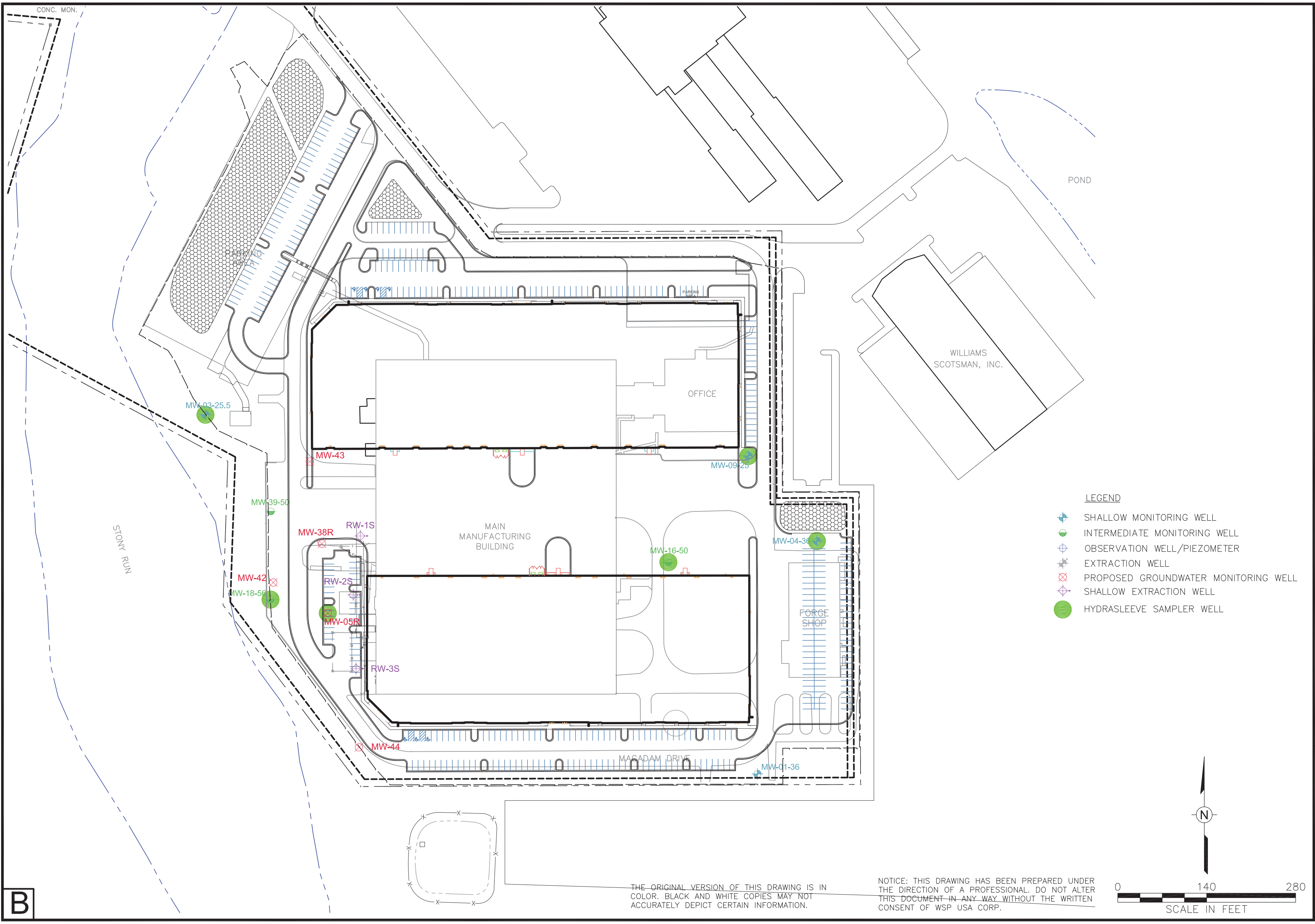

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FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Figure 14

SURFICIAL AQUIFER WELLS FOR
HYDRASLEEVE DEPLOYMENT DURING
FIELD DEMONSTRATION TEST

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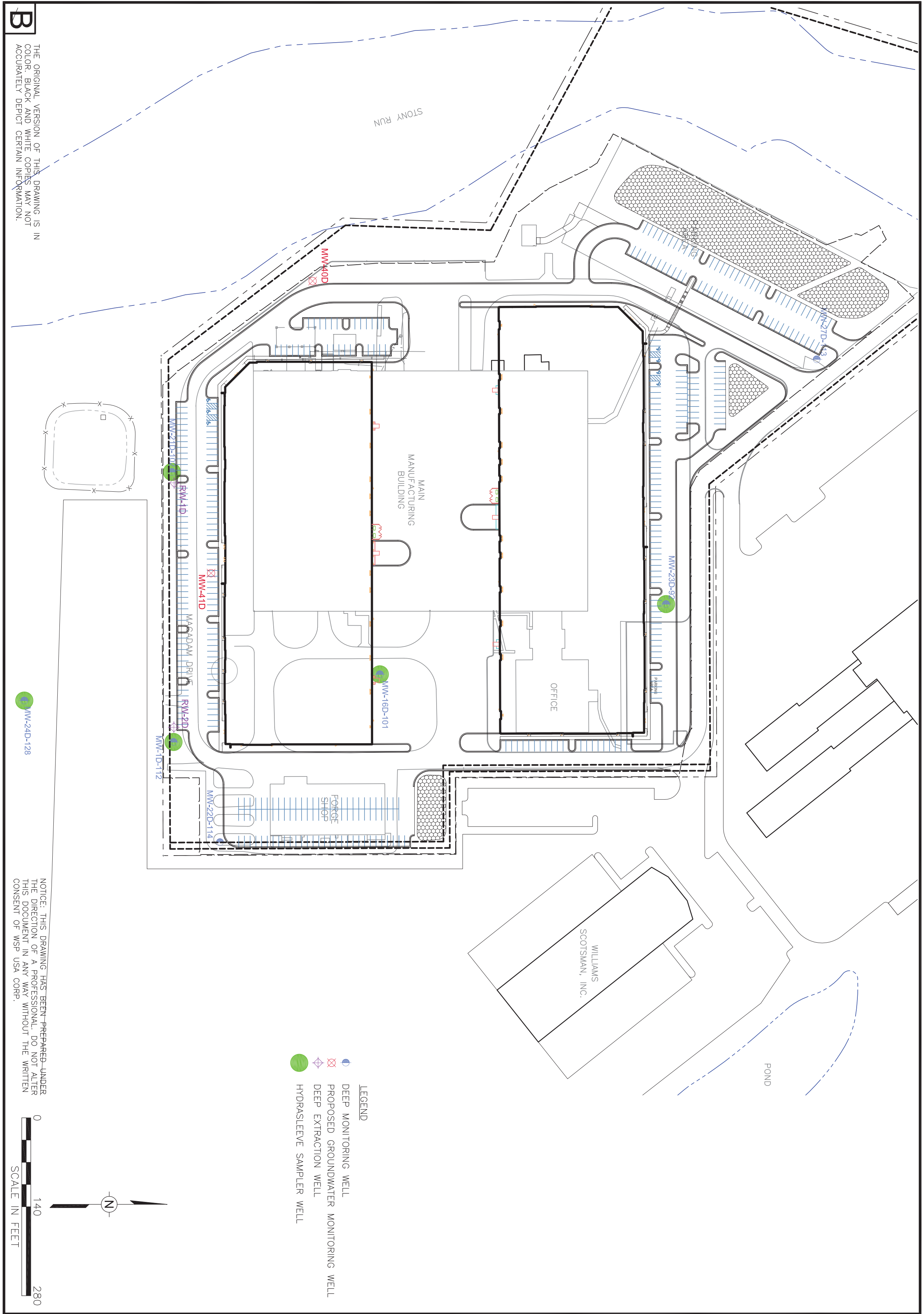

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Figure 15

LOWER PATAPSCO AQUIFER WELLS FOR
HYDRASLEEVE DEPLOYMENT DURING
FIELD DEMONSTRATION TEST

FORMER KOP-FLEX FACILITY
HANOVER, MARYLAND
PREPARED FOR
EMERSON
ST. LOUIS, MISSOURI

Drawn By: EGC
Checked:
Approved: RJ 4/13/2015
DWG Name: 00003705-224

Tables

Table 1

Groundwater Level Monitoring Networks
for Hydraulic Containment Systems
Former Kop-Flex Facility
Hanover, Maryland (a)

Surficial Aquifer		
MW-01	MW-16	MW-42 (b)
MW-03	MW-18	MW-43 (b)
MW-04	MW-20	MW-44 (b)
MW-05R	MW-38R	MW-45 (b)
MW-09	MW-39	
Lower Patapsco Aquifer		
MW-1D	MW-22D	MW-27D
MW-16D	MW-23D	MW-40D (b)
MW-21D	MW-24D	MW-41D (b)

a/ Monitoring networks do not include groundwater extraction wells.

b/ Monitoring well to be installed as part of the response action.

Table 2

Groundwater Quality Monitoring Network
Surficial Aquifer
Former Kop-Flex Facility
Hanover, Maryland

Well ID	Well Depth (feet bgs)	Screen Interval (feet MSL)		Sampling Rationale	Sampling Frequency
Monitoring Wells					
MW-03	25.5	89.2 - 99.2		Monitor COC concentrations downgradient of plume boundary	Annual
MW-04	36	89.4 - 99.4		Monitor COC concentrations upgradient of source area	Semi-annual
MW-05R	31	94.8 - 104.8		Monitor COC concentrations in plume area west of the main building	Semi-annual
MW-09	25	100.1 - 110.1		Assess COC concentrations in vicinity of source area	Semi-annual
MW-16	50	73.8 - 83.8		Assess COC concentrations in vicinity of source area	Semi-annual
MW-18	56	66.5 - 76.5		Assess downgradient extent of COC plume in lower sand unit	Semi-annual
MW-20	60	68.7 - 78.7		Monitor COC concentrations upgradient of source area	Semi-annual
MW-38R	28	95.1 - 105.1		Assess downgradient extent of COC plume in upper clayey unit	Semi-annual
MW-39	50	71.2 - 81.2		Assess downgradient extent of COC plume in lower sand unit	Semi-annual
MW-42 (a)	25	97 - 107		Assess downgradient extent of COC plume in upper clayey unit	Semi-annual
MW-43 (a)	40	82 - 92		Monitor COC concentrations north of extraction well system	Semi-annual
MW-44 (a)	40	85 - 95		Monitor COC concentrations south of extraction well system	Annual
Recovery Wells					
RW-1S	60 (b)	62 - 97	(c)	Monitor COC concentrations in extracted groundwater	Quarterly (d)
RW-2S	60 (b)	64.5 - 99.5	(c)	Monitor COC concentrations in extracted groundwater	Quarterly (d)
RW-3S	60 (b)	65 - 100	(c)	Monitor COC concentrations in extracted groundwater	Quarterly (d)

a/ Well depth and screen interval based on inferred geology; actual depths will be dependent on actual subsurface conditions.

b/ Depth from remedial system design; actual completion depth may vary based on subsurface conditions.

c/ Screen interval based on approximate ground surface elevation for proposed location and screen length of 35 feet.

d/ Sampling frequency to be decreased to semi-annual after one year of system operation.

Table 3

Groundwater Quality Monitoring Network
Lower Patapsco Aquifer
Former Kop-Flex Facility
Hanover, Maryland

Well ID	Well Depth (feet bgs)	Screen Interval (feet MSL)		Sampling Rationale	Sampling Frequency
Monitoring Wells					
MW-1D	112	17.1 - 27.7		Assess COC concentrations downgradient of source area	Semi-annual
MW-16D	101	22.3 - 32.5		Assess COC concentrations in the vicinity of source area	Semi-annual
MW-21D	102	21 - 31		Assess COC concentrations downgradient of source area	Semi-annual
MW-22D	114	14.3 - 24.3		Monitor COC concentrations near the eastern plume boundary	Semi-annual
MW-23D	92	30.1 - 40.1		Assess COC concentrations north of the source area	Semi-annual
MW-24D	128	0.7 - 10.7		Monitor COC concentrations in off-property portion of the plume	Semi-annual
MW-27D	113	2.6 - 12.6		Monitor background groundwater quality	Annual
MW-40D (a)	115 (b)	9 - 19	(b)	Monitor COC concentrations near the western plume boundary	Semi-annual
MW-41D (a)	160 (b)	(-36) - (-26)	(b)	Monitor COC concentrations in portion of the aquifer below the recovery wells	Annual
Recovery Wells					
RW-1D	140 (c)	(-17) - 23	(d)	Monitor COC concentrations in extracted groundwater	Quarterly (e)
RW-2D	140 (c)	(-12) - 28	(d)	Monitor COC concentrations in extracted groundwater	Quarterly (e)

a/ New monitoring well to be installed as part of the response action.
b/ Well depth and screen interval based on approximate ground surface elevation for proposed location and screen length of 10 feet.
c/ Depth from remedial system design; actual completion depth may vary based on subsurface conditions.
d/ Screen interval based on approximate ground surface elevation for proposed location and screen length of 40 feet.
e/ Sampling frequency to be decreased to semi-annual after one year of system operation.

Table 4

Monitoring Wells for HydraSleeve Field Demonstration Test Former Kop-Flex Facility Hanover, Maryland

Test Well	Screen Interval (feet bgs)		HydraSleeve Deployment Depth (feet bgs) (b)	Approximate HydraSleeve Sampling Depth (feet bgs) (c)
Surficial Aquifer				
MW-03	15.5 - 25.5		22	18.2 - 22
MW-04	26 - 36		33	29.2 - 33
MW-05R	20 - 30	(d)	27	23.2 - 27
MW-09	14 - 24		21	17.2 - 21
MW-16	40 - 50		47	43.2 - 47
MW-18	46 - 56		53	49.2 - 53
Lower Patapsco Aquifer				
MW-1D	102 - 112		109	105.2 - 109
MW-16D	91 - 101		97	93.2 - 97
MW-21D	92 - 102		99	95.2 - 99
MW-23D	82 - 92		86	82.2 - 86
MW-24D	118 - 128		123	119.2 - 123

a/ bgs = below ground surface
b/ Depth for the top of the HydraSleeve sampler.
c/ Sample interval equivalent to approximately 1.5x the length of a 2.5-foot long sampler.
d/ Replacement well for existing well MW-05; screen interval is approximate.

Appendix A – Quantitation Limits for VOC Analytical Method

Profile List

PASI Charlotte Laboratory

Client 92-WSP **Profile Number** 4362 **Line Item** 1

Line Item	Acode	Cmp List	Cmp	Analyte	CAS No.	PQL	MDL	Units	Sig Figs
1	1664 W92	1664 W92	og	Oil and Grease		5	1.1	mg/L	E
	1664 WH92	1664 WH92	tph	Total Petroleum Hydrocarbons		5	5	mg/L	E
	2540D W	2540D W	tssw	Total Suspended Solids		2.5	2.5	mg/L	E
	6010 W	6010 W	Al	Aluminum	7429-90-5	100	50	ug/L	E
			Cu	Copper	7440-50-8	5	2.5	ug/L	E
			Fe	Iron	7439-89-6	50	25	ug/L	E
			Pb	Lead	7439-92-1	5	2.5	ug/L	E
			Mn	Manganese	7439-96-5	5	2.5	ug/L	E
			Ni	Nickel	7440-02-0	5	2.5	ug/L	E
			thrd	Hardness, Total (SM 2340B)		662	662	ug/L	E
			Zn	Zinc	7440-66-6	10	5	ug/L	E
	6010 WD	6010 WD	Al	Aluminum	7429-90-5	100	25	ug/L	E
			Cu	Copper	7440-50-8	5	0.3	ug/L	E
			Fe	Iron	7439-89-6	50	14	ug/L	E
			Pb	Lead	7439-92-1	5	4	ug/L	E
			Mn	Manganese	7439-96-5	5	0.3	ug/L	E
			Ni	Nickel	7440-02-0	5	1.7	ug/L	E
			Zn	Zinc	7440-66-6	10	0.4	ug/L	E
	8260 WLL	8260 WLL	acet	Acetone	67-64-1	25	10	ug/L	E
			benz	Benzene	71-43-2	1	0.25	ug/L	E
			brob	Bromobenzene	108-86-1	1	0.3	ug/L	E
			bcoo	Bromochloromethane	74-97-5	1	0.17	ug/L	E
			brod	Bromodichloromethane	75-27-4	1	0.18	ug/L	E
			brof	Bromoform	75-25-2	1	0.26	ug/L	E
			broe	Bromomethane	74-83-9	2	0.29	ug/L	E
			2but	2-Butanone (MEK)	78-93-3	5	0.96	ug/L	E
			cate	Carbon tetrachloride	56-23-5	1	0.25	ug/L	E
			chlb	Chlorobenzene	108-90-7	1	0.23	ug/L	E
			choe	Chloroethane	75-00-3	1	0.54	ug/L	E
			chof	Chloroform	67-66-3	1	0.14	ug/L	E
			chom	Chloromethane	74-87-3	1	0.11	ug/L	E
			2clb	2-Chlorotoluene	95-49-8	1	0.35	ug/L	E
			4clb	4-Chlorotoluene	106-43-4	1	0.31	ug/L	E
			12dc	1,2-Dibromo-3-chloropropane	96-12-8	2	2	ug/L	E
			dibm	Dibromochloromethane	124-48-1	1	0.21	ug/L	E
			12do	1,2-Dibromoethane (EDB)	106-93-4	1	0.27	ug/L	E
			dimm	Dibromomethane	74-95-3	1	0.21	ug/L	E
			12db	1,2-Dichlorobenzene	95-50-1	1	0.3	ug/L	E
			13dc	1,3-Dichlorobenzene	541-73-1	1	0.24	ug/L	E
			14db	1,4-Dichlorobenzene	106-46-7	1	0.33	ug/L	E
			difm	Dichlorodifluoromethane	75-71-8	1	0.21	ug/L	E
			11da	1,1-Dichloroethane	75-34-3	1	0.32	ug/L	E
			12de	1,2-Dichloroethane	107-06-2	1	0.12	ug/L	E
			11dd	1,1-Dichloroethene	75-35-4	1	0.56	ug/L	E
			c12d	cis-1,2-Dichloroethene	156-59-2	1	0.19	ug/L	E
			t12d	trans-1,2-Dichloroethene	156-60-5	1	0.49	ug/L	E
			12dp	1,2-Dichloropropane	78-87-5	1	0.27	ug/L	E

Profile List

PASI Charlotte Laboratory

Client 92-WSP **Profile Number** 4362 **Line Item** 1

Line Item	Acode	Cmp List	Cmp	Analyte	CAS No.	PQL	MDL	Units	Sig Figs
1	8260 WLL	8260 WLL	13dp	1,3-Dichloropropane	142-28-9	1	0.28	ug/L	E
			22dp	2,2-Dichloropropane	594-20-7	1	0.13	ug/L	E
			11dp	1,1-Dichloropropene	563-58-6	1	0.49	ug/L	E
			c13d	cis-1,3-Dichloropropene	10061-01-5	1	0.13	ug/L	E
			t13d	trans-1,3-Dichloropropene	10061-02-6	1	0.26	ug/L	E
			diie	Diisopropyl ether	108-20-3	1	0.12	ug/L	E
			14dx	1,4-Dioxane (p-Dioxane)	123-91-1	150	78.36	ug/L	E
			eben	Ethylbenzene	100-41-4	1	0.3	ug/L	E
			h13b	Hexachloro-1,3-butadiene	87-68-3	1	0.71	ug/L	E
			2hex	2-Hexanone	591-78-6	5	0.46	ug/L	E
			pcpi	p-Isopropyltoluene	99-87-6	1	0.31	ug/L	E
			mech	Methylene Chloride	75-09-2	2	0.97	ug/L	E
			mibk	4-Methyl-2-pentanone (MIBK)	108-10-1	5	0.33	ug/L	E
			metb	Methyl-tert-butyl ether	1634-04-4	1	0.21	ug/L	E
			naph	Naphthalene	91-20-3	1	0.24	ug/L	E
			styr	Styrene	100-42-5	1	0.26	ug/L	E
			11tc	1,1,1,2-Tetrachloroethane	630-20-6	1	0.33	ug/L	E
			11te	1,1,2,2-Tetrachloroethane	79-34-5	1	0.4	ug/L	E
			tece	Tetrachloroethene	127-18-4	1	0.46	ug/L	E
			tolu	Toluene	108-88-3	1	0.26	ug/L	E
			12tb	1,2,3-Trichlorobenzene	87-61-6	1	0.33	ug/L	E
			12b4	1,2,4-Trichlorobenzene	120-82-1	1	0.35	ug/L	E
			11t1	1,1,1-Trichloroethane	71-55-6	1	0.48	ug/L	E
			11t2	1,1,2-Trichloroethane	79-00-5	1	0.29	ug/L	E
			trce	Trichloroethene	79-01-6	1	0.47	ug/L	E
			trcf	Trichlorofluoromethane	75-69-4	1	0.2	ug/L	E
			12tp	1,2,3-Trichloropropane	96-18-4	1	0.41	ug/L	E
			vace	Vinyl acetate	108-05-4	2	0.35	ug/L	E
			vcrd	Vinyl chloride	75-01-4	1	0.62	ug/L	E
			txyl	Xylene (Total)	1330-20-7	2	0.66	ug/L	E
			mpxy	m&p-Xylene	179601-23-1	2	0.66	ug/L	E
			oxyl	o-Xylene	95-47-6	1	0.23	ug/L	E
	8260 WSIM	8260 WSIM	14dx	1,4-Dioxane (p-Dioxane)	123-91-1	2	1.9	ug/L	E

*The MDLs listed are not instrument specific.

*Signficant Figures:

Numeric Value - The actual number of significant figures

E (EPA) - Numbers less than 10 have 2 significant figures and numbers greater than or equal to 10 have 3 significant figures

M (Metals) - Numbers less than 100 have 2 significant figures and numbers greater than or equal to 100 have 3 significant figures

O (Organics) - Numbers less than 1 have 1 significant figure, numbers less than 100 but not less than 1 have 2 significant figures, and numbers greater than or equal to 100 have 3 significant figures.

Appendix B – WSP Standard Field Operating Procedures

FIELD STANDARD OPERATING PROCEDURE #1
Note Taking and Field Book Entries Procedure

The field book is a record of the day's activities that serves as a reference for future reporting and analyses. The field book is also a legal record for projects that may become involved in litigation. It is of the utmost importance that your notes be complete and comprehensive. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) before beginning any onsite activities.

1.1 Acronyms and Abbreviations

HASP	health and safety plan
IDW	investigation-derived waste
SOP	standard operating procedure

1.2 Materials

- Permanently-bound waterproof field book (e.g., Rite-in-the-Rain® #550, or equivalent)
- Black or blue ballpoint pen (waterproof ink recommended; do not use felt-tip pens)

1.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

The purpose of the field book is to provide a log of all of field events and conditions. The notes must include sufficient detail (i.e., who, what, when, where, why, and how) to enable others to reconstruct the day's activities for analysis, reporting, or litigation. It is important to be objective, factual, and thorough. Language must be free of personal comments or terminology that might prove inappropriate. Additional data logs or worksheets, such as low flow groundwater sampling sheets, may be used as a supplement; however, under no circumstances should the data sheets be used as a substitute for the daily record of events to be recorded in the field book.

The field book forms the foundation upon which most of the project work (reports, subsequent work plans, etc.) will be based. It is critical that field book chain of custody is maintained at all times.

1.4 Set-Up Procedures

The first step in setting up a new field book is to add the information necessary for you to identify the field book in the future and for others to return the book to WSP, should it be lost. On the first page of the field book (or, for some field books, the inside cover), place a “Return for Reward” notice. Include the following information:

- An “If Found – Return for Reward” notice in bold letters
- Our company name
- Our company address (usually the office where the project is being managed)
- Our company phone number

Reserve the second page of the field book for project-specific information, such as:

- The project name and number
- The project manager’s name
- The site telephone number, address, and onsite contact (if appropriate)
- The names and telephone numbers for all key (onsite) personnel
- The emergency telephone numbers including the police, fire, and ambulance (found in the HASP)

Business cards from individuals who visit the site, (including the person in charge of the field book) can be affixed to the inside back cover.

1.5 Field Book Entries

Start each day on a new page. Include the following information in the header of the first page (and all subsequent pages):

- The date
- The project name
- The page number (often pre-printed in Rite-in-the-Rain® style field books)

Precede field book entries by the time entered along the left margin of the page using a 24-hour or military clock (e.g., 1330 for 1:30 PM). The first entry of the day must include your and your subcontractor’s arrival time at the site, a description of the planned activities, key onsite personnel (including subcontractors), and the weather forecast. The first entry must also detail the tailgate review of the site-specific HASP with the onsite personnel. Be sure that field book entries are LEGIBLE and contain factual, accurate, and inclusive documentation of project field activities. Do not leave blank lines between field book entries. If a mistake is made in an entry, cross out the mistake with a single line and place your initials the end of the line. Any acronyms written in the field book (including your initials) must be spelled out prior to the first use. Record your initials and date at the bottom of each page.

Subsequent log entries must document the day’s activities in sequence and must be completed throughout the day as events occur (i.e., do not wait until the end of the work day to complete the notes); should out of sequence notes need to be entered, please identify using a footnote or by clearly indicating “Late Entry.” Notes must be descriptive and provide location information or diagrams (if appropriate) of the work area or sample locations. Note any changes in the weather and document all deviations from the work plan. Arrival and departure times of all personnel, and operational periods of standby, decontamination, and specific activities must be recorded.

List all field equipment used (e.g., photoionization detector, water testing equipment, personal protective equipment, etc.) and equipment calibration activities, and record field measurements, including distances, monitoring and testing instrument readings. Include the following information in entries describing sampling activities:

- The equipment and materials used by subcontractors, if appropriate (e.g., drill rig type, boring sizes, well casing materials, etc.)
- The sample media and analyses to be performed

- The sampling procedures (e.g., split-spoon sampling, hand trowel, low flow, etc.)
- The equipment used to obtain the sample (e.g., bailers, pump types, geochemical monitoring equipment, etc.)
- The sizes and types of containers, preservation (if any), and any resulting reactions
- The sample identification (especially for duplicate samples)
- The sample collection time
- The shipping and handling procedures, including chain-of-custody, air bill, and seal numbers
- If supplemental data recording logs (digital or hard copy), such as low flow groundwater sheets, the above information must be entered in the field book and the supplemental records cross-referenced.

For most sampling activities, the log entries must also include:

- The decontamination and disposal procedures for all equipment, samples, and protective clothing
- An inventory of the investigation-derived waste (IDW) materials generated during the site activities
- A description of the IDW labeling procedures and the onsite staging information

Maintain a sequential log if the sample locations and areas of interest are photographed (strongly recommended). The photographic log must include:

- The date and time of the photograph
- The sequential number of the photograph (e.g., photograph-1, photograph-2, etc.)
- The general direction faced when the photograph was made
- A description of the subject in the image

1.6 Closing Notes

The last entry of the day must include a brief wrap up of the work accomplished, a description of how the site is being secured, and a description of any near hits, accidents, and incidents that occurred during the day’s work. Draw a line through the remainder of the page from the row of text diagonally through any blank lines and initial at the end of the diagonal line.

FIELD STANDARD OPERATING PROCEDURE #3
Sample Packaging and Shipment Procedure

Shipping samples is a basic but important component of field work. Nearly all of the WSP activities include the collection of environmental samples. Proper packing and preservation of those samples is critical to ensuring the integrity of WSP's work product. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

3.1 Acronyms and Abbreviations

CFR	Code of Federal Regulations
DOT	U.S. Department of Transportation
IATA	International Air Transport Association
HASP	health and safety plan
PPE	personal protective equipment
SOP	standard operating procedure

3.2 Materials

- Suitable shipping container (e.g., plastic cooler or lab-supplied styrofoam-insulated cooler)
- Chain-of-custody forms
- Custody seals
- WSP mailing labels
- Tape (Strapping, clear packing, or duct tape)
- Heavy-duty zipper-style plastic bags
- Knife or scissors
- Permanent marker
- PPE
- Large plastic garbage bag
- Wet ice (as necessary)
- Bubble wrap or other packing material
- Universal sorbent materials
- Sample container custody seals (if required)
- Shipping form (with account number)

3.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for shipping samples and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample collection and quality assurance procedures (SOP 4), and investigation derived waste management procedures (SOP 5), and has a current certificate for WSP's U.S. Department of Transportation (DOT) Hazardous Materials training.

> **NOTE: WSP employees shipping samples regulated as hazardous materials or exempt hazardous materials by air must have International Air Transport Association (IATA) training. IATA training is a separate training required in addition to DOT hazardous materials training for such shipments. Most WSP employees do not have IATA training and therefore, anyone who needs to ship by air MUST consult with a WSP IATA-trained compliance professional. The remainder of Section 3.3 covers shipments regulated by DOT only.**

Environmental samples can meet the definition of DOT hazardous materials when shipped by air, ground, or rail from a project site to the laboratory. As such, field staff must work with their assigned WSP compliance professional to determine whether the sample shipment is subject to any specific requirements (e.g., packaging, marking, labeling, and documentation) under the DOT hazardous materials regulations.

Title 49 Code of Federal Regulations (CFR) Section 171.8 defines a "hazardous material" as a substance which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. DOT hazardous materials are listed in the hazardous materials table at 49 CFR 172.101.

In most cases, WSP is collecting environmental samples in order to determine whether any hazardous chemicals are present in the sampled media. Therefore, we would not have the appropriate information to make a hazardous materials classification for the samples prior to shipment. 49 CFR 172.101(c)(11) allows the use of a tentative classification where the shipper is uncertain of the material's hazard class. Where WSP does not know the physical characteristics of the samples, a non-hazardous material classification may be made. Non-hazardous materials are not subject to the DOT hazardous materials regulations.

There are certain cases where the characteristics and hazard class of the samples are known (e.g., samples of free product, samples preserved with a hazardous material [TerraCore® samplers]). Contact your assigned WSP compliance professional or an internal DOT contact for guidance on shipment of these materials.

3.4 Sample Shipment Procedures

The two major concerns in shipping samples are incidental breakage during shipment and complying with applicable DOT and courier requirements for hazardous materials shipments.

> **NOTE: Many couriers, including Federal Express and UPS, have requirements that WSP register with them before shipping hazard materials. In most cases, it is the sampling location, not the WSP office address, which needs to be registered. Therefore, each project will likely have unique requirements. Please contact your WSP compliance**

professional to determine whether or not you will be required to register for your shipment.

Protecting the samples from incidental breakage can be achieved using "common sense." Pack all samples in a manner that will not allow them to freely move about in the cooler or shipping container. Do not allow glass surfaces to contact each other. When possible, repack the sample containers in the same materials that they were originally received in from the laboratory. Cushion each sample container with plastic bubble wrap, styrofoam, or other nonreactive cushioning material. A more detailed procedure for packing environmental samples is presented below.

3.4.1 Non-Hazardous Material Environmental Samples

The first step in preparing your samples for shipment is securing an appropriate shipping container. In most cases, the analytical laboratory will supply an insulated cooler for the bottle shipment, which can be used to return the samples once they have been collected. Be sure that the container is sufficiently large to contain both your samples, cushioning material, and enough wet ice to maintain the samples at the preservation temperature (usually 4° Celsius). Do not use lunch-box sized coolers or soft-sided coolers, which do not offer sufficient insulation or protection from damage.

Place universal sorbent materials (e.g., sorbent pads, Pig-brand absorbent blankets) in the bottom of the shipping container. The amount of sorbent material must be sufficient to absorb any condensation from the wet ice and a reasonable volume of water from melted wet ice (if a bag were to rupture) or a damaged (aqueous) sample container. If using a plastic cooler with a drain, securely tape the inside of the drain plug with duct tape or other material to ensure that no water leaks from the cooler during shipment.

The next step is to line the shipping container with a large, heavy-duty plastic garbage bag. Place 2 to 4 inches of bubble wrap or other appropriate packing material inside the heavy-duty plastic bag in the bottom of the shipping container to form a cushion for the sample containers. Place the samples on the packing materials with sufficient space to allow for the addition of more bubble wrap or other packing material between the sample containers. Place large or heavy sample containers on the bottom of the cooler with lighter samples placed on top to minimize the potential for breakage. Place all sample containers in the shipping container right-side up. Do not overfill the cooler with samples; leave sufficient room for the wet ice if the samples are to be preserved during transit.

Place wet ice to be used for sample preservation inside two sealed heavy-duty zipper-style plastic bags (1 gallon-sized, or less). Place the bags of ice on top of or between the samples. Place as much ice as possible into the cooler to ensure the samples arrive at the lab at the required preservation temperature, even if the shipment is delayed. Fill any remaining space with bubble wrap or other packing material to limit the airspace and minimize the in-transit melting. Securely close and seal, with tape, the top of the heavy-duty plastic bag. Place the original, white top copy chain-of-custody form into a heavy-duty zipper-style plastic bag, affix the bag to the shipping container's inside lid, and then close the shipping container. Sample shipment preparations are complete if using a laboratory courier.

If sending the sample shipment through a commercial shipping vendor, place two signed and dated chain-of-custody seals on alternate sides of the shipping container lid so that it cannot be opened without breaking the seals. Securely fasten the top of the shipping container shut with clear packing tape; carefully tape over the custody seals to prevent damage during shipping. Once the shipping container is sealed, shake test the shipping container to make sure that there are no loose sample containers. If loose sample containers are detected, open the shipping container, repack the sample containers, and reseal the shipping container.

Using clear tape, affix a mailing label with WSP's return address to the top of the shipping container. Ship environmental samples to the contracted analytical laboratory using an appropriate delivery schedule. If applicable, check the appropriate box on the airbill for Saturday delivery (you need to verify with the laboratory that someone will be at the lab on a Saturday to receive the sample shipment). Declare the value of samples on the shipping form for insurance purposes, if applicable, and be sure to include the project billable number on the shipping form's internal billing reference section. When shipping samples to a lab, identify a declared value equal to the carrier's default value ($100); additional fees will be charged based on a higher value declared. Our preferred carrier, FedEx, will only reimburse for the actual value of the cooler and its contents if a sample shipment is lost; they will not reimburse for the cost of having to re-collect the samples. [Please note: if you are shipping something other than samples, such as field equipment, declare the replacement value of the contents.]

Record the tracking numbers from the shipping company forms (i.e., the airbill number) in the field book and on the chain-of-custody form and retain a copy of the shipping airbill. On the expected delivery date, confirm sample receipt by contacting the laboratory or tracking the package using the tracking number; provide this confirmation information to the WSP project manager.

3.4.2 Hazardous Materials Samples

WSP personnel rarely ship hazardous materials due to DOT shipping requirements. If you find that your samples could be considered a DOT hazardous material, first coordinate with the assigned WSP compliance professional and project manager to make a hazardous material classification and, if necessary, establish the necessary protocols and to receive the appropriate training/certification. **Do not ship hazardous materials samples without first consulting a WSP compliance professional.**

FIELD STANDARD OPERATING PROCEDURE #4
Sample Collection and Quality Assurance Procedure

The purpose of this procedure is to assure that sample volumes and preservatives are sufficient for analytical services required under U.S. Environmental Protection Agency (EPA) or other agency approved protocols. This operating procedure describes the ways and means of selecting the appropriate sampling containers for environmental sampling. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

4.1 Acronyms and Abbreviations

ºC	degrees Celsius
COC	chain-of–custody [form]
DI	deionized water
DOT	U.S. Department of Transportation
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
HASP	health and safety plan
MS/MSD	matrix spike and matrix spike duplicate
MSA	Master Service Agreement
PPE	personal protective equipment
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
SOP	standard operating procedure
VOCs	volatile organic compounds

4.2 Materials

- Field book
- Indelible (waterproof) markers or pens
- PPE
- Sample containers
- Sample labels
- Clear tape
- Deionized (DI) water
- Cleaned or dedicated sampling equipment

4.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for collecting environmental and quality assurance samples and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), investigation derived waste management procedures (SOP 5), and equipment decontamination (SOP 6). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a site-specific work plan or a dedicated quality assurance project plan.

4.4 Sample Identification Procedures

Information on the sample labels must contain the site/project name, project/task number, unique alpha-numeric sample identification (ID) number, sample date, time of collection using the military or 24-hour clock system (e.g., 0000 to 2400 hours), analytical parameters, preservative, and sampling personnel. WSP personnel are advised to use pre-printed waterproof mailing labels (e.g., Avery® 5xxx Waterproof Address Labels) for all sample identification. WSP templates for the labels are available in each office.

The sample identification number must, unless otherwise approved by your project manager or specified in your site-specific work plan, follow the WSP naming protocol. This protocol was developed to aid in determining the type of sample collected (e.g., soil, groundwater, vapor, etc.), the sample location, and, where appropriate, the sample depth. The protocol was also designed to ensure consistency across the company.

Construct sample IDs in the following format:

SB-10A (4-6)

Where, in this example:

SB = the first two or three characters will define the sample type (see list of approved prefixes below); in this case, a soil boring

10A = the next two or three alpha-numeric digits (separated by a dash from the sample type identifier) indicate the location of the boring on the site; in this case, boring number 10A

(4-6) = the depth the sample was collected, with the first number (including decimals, if necessary) indicating the top of the sample interval and the second number indicating the bottom of the sample interval; not all sample types will include depth information.

Additional label information may be added after the last character of the sample ID (e.g., sample date, underground storage tank number, area of concern number, “Area” number, Client Identifier, etc.). Separate any additional information from the required portion of the sample name by dash(es).

Sample Prefix	Permitted Use
AA -	Ambient outdoor air samples
CC -	Concrete core/chip sample
CS -	Confirmation/verification soil samples collected from an excavation
HA -	Soil samples collected with a hand auger
IAB -	Indoor air samples – basement
IAC -	Indoor air samples – crawl space
IAF -	Indoor air samples – first floor
MW -	Soil samples collected from a monitoring well borehole or a groundwater sample collected from a monitoring well
PZ -	Groundwater samples collected from a piezometer
SB -	Soil samples collected from boreholes that will not be converted to monitoring wells
SED -	Sediment samples
SG -	Soil gas samples other than sub-slab samples (e.g., samples collected from temporary or permanent PVC sample points or stainless steel screen implants)
SL -	Sludge samples
SS -	Surface soil samples collected using hand tools (e.g., trowel, spoon, etc.) and typically at depths less than 2 feet below ground surface
SSV -	Sub-slab vapor samples
SW -	Surface water samples
TC -	Tree core samples
TP -	Soil samples collected from a test pit
WC -	Waste characterization samples
WP -	Wipe samples

4.5 Sample Containers, Preservatives, and Holding Times

The first step in sample collection is to verify that the analytical laboratory has provided the correct number and type of sample containers and each contains the appropriate preservatives for the proposed project (i.e., check against the sampling plan requirements outlined in the site-specific Quality Assurance Project Plan [QAPP]). Inspect all containers and lids for flaws (cracks, chips, etc.) before use. Do not use any container with visible defects or discoloration. Report any discrepancies, or non-receipt, of specific types of sample containers to the team leader or project manager immediately. Make arrangements with the laboratory to immediately ship missing or additional sampling containers.

Take special effort to prevent cross contamination and contamination of the environment when collecting samples. Protect equipment, sample containers and supplies from accidental contamination. Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to sampling. The gloves must not come in contact with the medium being sampled and must be changed any time during sample collection when their cleanliness is compromised. Sample collection must follow all appropriate SOPs and state and federal regulations, or guidance, for the collection of environmental samples; the recommended order of sample collection is:

- Geochemical measurements (e.g., temperature, pH, specific conductance)

- Volatile organic compounds (VOCs)
- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Total metals
- Dissolved metals
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Collected samples that require thermal preservation must be immediately (within 15 minutes) placed in a cooler with wet ice and maintained at a preservation temperature of 4° Celsius (C).

4.6 Field Quality Assurance/Quality Control Samples

Field quality assurance/quality control (QA/QC) samples include equipment blanks, trip blanks, duplicates, and split samples. The project manager or QAPP must specify the type and frequency of QA/QC sample collection. The QA/QC sample identification number must, unless otherwise approved by your project manager or specified in your site-specific work plan, follow the WSP naming protocol as discussed in the sections below. QA/QC samples must be clearly identified on WSP's copy of the COC form and in the field book. Failure to properly collect and submit required QA/QC samples can result in invalidation of an entire sampling event.

Collect, preserve, transport and document split samples using the same protocols as the related samples.

4.6.1 Equipment Blanks

Equipment blanks are used to document contamination attributable to using non-dedicated equipment. Collect equipment blanks in the field at a rate of one per type of equipment per day, unless otherwise specified. If the site-specific work plan or QAPP indicates that an equipment blank is to be collected from dedicated sampling equipment, collect the equipment blank in the field before sampling begins. If field decontamination of sampling equipment is required, prepare the equipment blanks after the equipment has been used and field-decontaminated at least once. Prepare equipment blanks by filling or rinsing the pre-cleaned equipment with laboratory provided analyte-free water and collecting the rinsate in the appropriate sample containers. The samples must be labeled, preserved, and filtered (if required) in the same manner as the environmental samples. Record the type of sampling equipment used to prepare the blank. Have the equipment blanks analyzed for all the analytes for which the environmental samples are being analyzed, unless otherwise specified. Decontamination of the equipment following equipment blank procurement is not required. If laboratory-grade DI water is unavailable, store-grade distilled water can be used to prepare these blanks. If store-grade distilled water is used, be sure to record the source and lot number in the field book. Designate equipment blanks using “EB”, followed by the date, and in the order of equipment blanks collected that day. For example, the first equipment blank collected on July 4, 2013, would be designated EB070413-1.

4.6.2 Trip Blanks

Trip blanks are used to document VOC contamination attributable to shipping and field handling procedures. Trip blanks are only required when analyzing samples for VOCs. Trip blank(s) will be prepared at the laboratory and will be sent to the facility along with sample containers. Never open trip blank sample bottles, but label them in the field and return them to the laboratory in the same shipping container in which the trip blank sample bottles arrived at the site. Keep the trip blank sample bottles in the same shipping container used to ship and store VOC sample bottles during the sampling event. To minimize the number of trip blanks needed per shipment, if possible, ship all of the VOC samples in the same shipping container with the trip blank. If laboratory-provided trip blanks are not available, DI water, or store-grade distilled water and clean, empty VOC sample bottles can be used to prepare additional trip blanks. If store-grade distilled water is used, be sure to record the source and lot number in the field book. Identify trip blanks using “TB”, followed by the date. For example, the trip blank shipped with a cooler of samples on July 4, 2013, would be designated TB070413-1. If a second trip blank is needed on that same day, the designation would be TB070413-2.

4.6.3 Temperature Blank

Temperature blanks are used to determine if proper sample thermal preservation has been maintained by measuring the temperature of the sample container upon arrival at the laboratory. A temperature blank should be included in each sample cooler used to ship and store the sample bottles during the sampling event. If laboratory-provided temperature blanks are not available, fill a clean, unpreserved sample bottle with potable, DI, or store-grade distilled water and identify the bottle as a temperature blank.

4.6.4 Duplicates

Duplicates are useful for measuring the variability and documenting the precision of the sampling process. Unless more stringent project requirements are in place, collect duplicate samples at least at a rate of 1 per 20 samples collected. Under no circumstances can equipment or trip blanks be used as duplicates. Sample locations where sufficient sample volume is available and where expected contamination is present should be selected for sample duplication.

Collect each duplicate sample at the same time, from the same sample aliquot and in the same order as the corresponding field environmental sample. When collecting aqueous duplicate samples, alternately fill sample bottle sets (i.e., the actual sample bottle and the bottle to be used for the duplicate) with aqueous samples from the same sampling device. If the sampling device does not hold enough volume to fill the sample containers, fill the first container with equal portions of the sample, and pour the remaining sample into the next sample containers. Obtain additional sample volume and pour the first portion into the last sample container, and pour the remaining portions into the first containers. Continue with these steps until all containers have been filled.

Duplicate samples will be assigned arbitrary sample ID and a false collection time so that they are not identified as duplicates by the laboratory (i.e., submit the samples blind to the lab). The blind duplicate sample "location designation" will be left up to the project manager; however, in no case will "Dup" be allowed to appear in the sample name. Have the duplicate samples analyzed for the same analytes as the original sample. Be sure to record the duplicate sample ID, the false time, and the actual time of collection in the field notebook. The duplicate should also be indicated on WSP’s carbon copy of the chain-of-custody.

4.6.5 Matrix Spike and Matrix Spike Duplicates

Matrix spike and matrix spike duplicate samples, known as MS/MSD samples, are used to determine the bias (accuracy) and precision of a method for a specific sample matrix. Many of WSPs projects require the collection of MS/MSD samples; however, laboratory generated MS/MSD samples are sufficient for some projects. As required by your QAPP or site-specific work plan, collect MS/MSD samples at the required ratio; if the sampling ratio is not specified by your QAPP or site-specific work plan, collect MS/MSD samples at a rate of 1 for every 20 samples. Clearly convey the MS/MSD identity to the laboratory by adding “MS" or "MSD” after the sample name (e.g., MW-01MS) or in the comments section of the chain-of-custody. Under no circumstances can equipment or trip blanks be used as MS/MSD samples.

4.6.6 Split Samples

Split samples may be collected as a means of determining compliance or as an added measure of quality control. Unlike duplicate samples that measure the variability of both the sample collection and laboratory procedures, split samples measure only the variability between laboratories. Therefore, the laboratory samples must be subsamples of the same parent sample and every attempt must be made to ensure sample homogeneity. Collect aqueous split samples in the same manner as a duplicate sample.

Collecting split samples of soils, sediments, wastes, and sludge is not recommended because the homogenization necessary for a true split sample in these matrices is not possible.

Spilt samples should have the same sample location (e.g., MW-01, SB-03 (4-6), but differentiated from each other by inserting the laboratory analyzing or the agency/consultant collecting the sample after the sample location (e.g., MW-01-WSP and MW-01-EPA).

4.7 Custody Documentation

Sample custody protocols are used to demonstrate that the samples and sample containers were handled and transferred in such a manner as to eliminate possible tampering. Legal chain of custody (COC) begins when the pre-cleaned sample containers are dispatched to the field from the laboratory and continues through the sample analysis and eventual disposal. Maintaining custody requires that samples must be in the actual possession or view of a person who is authorized to handle the samples (e.g., sample collector, laboratory technician), secured by the same person to prevent tampering, or stored in a designated secure area.

It is a good idea to limit, to the extent possible, the number of individuals who physically handle the samples. Samples must be placed in locked storage (e.g., locked vehicle, locked storeroom, etc.) at all times when not in the possession or view of authorized personnel. Do not leave samples in unoccupied motel or hotel rooms or other areas where access cannot be controlled by the person(s) responsible for custody without first securing samples and shipping or storage containers with tamper-indicating evidence tape or custody seals

The COC form is used to trace sample possession from the time of collection to receipt at the laboratory. Although laboratories commonly supply their own COC form, it is recommended that WSP's COC be used to ensure that all necessary data are recorded. At a minimum, the COC needs to have a unique COC number, accompany all the samples, and include the following information:

- Project number, name, and location
- Sampler's printed name(s) and signature(s)
- Sample identification number
- Date and time (military time) of collection
- Sample matrix
- Total number of containers per sample
- Parameters requested for analysis including number of containers per analyte
- Remarks (e.g., irreducible headspace, field filtered sample, expected concentration range, specific turn-around time requested, etc.)
- Signatures of all persons involved in the chain of possession in chronological order
- Requested turn-around-time
- Name and location of analytical laboratory
- Custody seal numbers
- Shipping courier name and tracking information
- Internal temperature of shipping container upon shipment to laboratory, as needed
- Internal temperature of shipping container upon delivery to laboratory

- WSP contact information

Affix tamper-indicating evidence tape or seals to all storage and shipping container closures when transferring or shipping sample container kits or samples to an off-property party. Place the seal so that the closure cannot be opened without breaking the seal. Record the time, calendar date and signatures of responsible personnel affixing and breaking all seals for each sample container and shipping container. Affix new seals every time a seal is broken until continuation of evidentiary custody is no longer required.

FIELD STANDARD OPERATING PROCEDURE #5
Investigation Derived Waste Management Procedure

The purpose of this standard operating procedure (SOP) is to provide instructions for handling, storing, and managing Investigation Derived Waste (IDW) pending disposal. All IDW, which includes (but is not limited to) soil cuttings, development water, purge water, drilling fluids, decontamination fluids, personal protective equipment (PPE), and sampling equipment, must be managed in compliance with applicable or relevant and appropriate requirements. The user is advised to read the entire SOP and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

5.1 Acronyms and Abbreviations

DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
HASP	health and safety plan
IDW	investigation derived waste
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
SOP	standard operating procedure
TSCA	Toxic Substances Control Act

5.2 Materials

- Non-hazardous waste, hazardous waste, and/or polychlorinated biphenyl (PCB) labels
- Investigation derived waste (IDW) log (figure 1)
- Permanent ink marking pen, paint, stick/pen
- Sampling equipment (refer to sampling SOPs)
- Impermeable covers (e.g., tarps), as needed
- Duct tape, rope, or other material to secure tarp
- Copy of the waste manifest or bills of lading

5.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for handling, storing, and managing IDW pending disposal and assumes the user holds a current U.S. Department of Transportation (DOT) training and Resource Conservation and Recovery training (if required) certificates and is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), and equipment decontamination (SOP 6). The SOP does not cover investigation planning, DOT regulations, nor does it cover the evaluation of the analytical results. **Consult and involve WSP's compliance professionals during all phases of IDW management and disposal.**

5.4 IDW General Procedures

Nearly all intrusive field activities performed at WSP will generate solid or liquid wastes. Examples include:

Solid Wastes	**Liquid Wastes**
■ Soil Cuttings	■ Decontamination water
■ Drilling mud	■ Development water
■ Plastic sheeting	■ Drilling fluids
■ Spent carbon or filters (e.g., bag filters)	■ Purge water
■ PPE (e.g., Tyvek, gloves, respirator cartridges, etc.)	■ Soap or wash solutions
■ Disposable or dedicated sampling equipment (e.g,, bailers, hose, clamps, buckets, cartridge filters, etc.)	■ Reagents (e.g,, hexane, nitric acid, methanol, etc.)
■ Field analytical waste (HACH kits, Chlor-n-Soil kits, etc.)	

The specific procedures for dealing with these materials after the field activities have been completed will vary depending on whether the materials are considered non-hazardous, Resource Conservation and Recovery Act (RCRA) hazardous (characteristic or listed wastes), or contain PCBs at concentrations above 50 milligrams per kilogram (i.e., PCB wastes regulated under the Toxic Substances Control Act [TSCA]). The characterization of the wastes to be generated is ideally determined in conjunction with a WSP compliance professional before the field event occurs, based on previously generated data; however, in some cases, particularly for new sites, the status of the wastes may not be known. In these cases, handle IDW as hazardous waste until the status can be verified. Field personnel must consult their assigned WSP compliance professionals for assistance in proper waste characterization.

It is important to note that information contained in this SOP is based on federal regulations and interpretive guidance provided by the U.S. Environmental Protection Agency (EPA) and other federal regulatory sources; therefore, information provided in this SOP may be superseded by state or local-specific statutes or regulations. Field personnel must discuss the handling procedures with the project manager and assigned WSP compliance professional before mobilizing to the field.

5.4.1 Waste Minimization

Select investigation methods and techniques that will minimize the amount of wastes generated during field activities, particularly if the IDW is hazardous. Examples include using direct-push methods instead of hollow stem augers (to minimize soil cuttings) during a soil investigation, if appropriate, and limiting contact with the materials to reduce the amount of PPE required. Minimizing the amount of waste generated will reduce handling requirements and overall project costs, and is consistent with WSP's corporate goals for sustainability.

5.4.2 Hazardous Waste Generator Status

The hazardous waste generator requirements that pertain to a site depend on how much hazardous waste is generated at a site in a calendar month. In coordination with your assigned WSP compliance professional, determine the site's hazardous waste generator status (conditionally exempt, small, or large quantity generator) before site work begins and inform the site contact and/or client representative of the quantity of hazardous waste that will be generated as a result of its activities.

The following table provides a summary of requirements for each class of hazardous waste generator: Conditionally Exempt Small Quantity Generators (CESQGs), Small Quantity Generators (SQGs), and Large Quantity Generators (LQGs). Note that this is provided for guidance purposes only and should not substitute for close coordination with your assigned WSP compliance professional for all IDW-related activities.

	CESQGs	**SQGs**	**LQGs**
Quantity Limits	≤100 kg/month ≤1 kg/month of acute hazardous waste ≤100 kg/month of acute spill residue or soil §§261.5(a) and (e)	Between 100 - 1,000 kg/month §262.34(d)	≥1,000 kg/month >1 kg/month of acute hazardous waste >100 kg/month of acute spill residue or soil Part 262 and §261.5(e)
EPA ID Number	Not required §261.5	Required §262.12	Required §262.12
On-Site Accumulation Quantity	≤1,000 kg ≤1 kg acute ≤100 kg of acute spill residue or soil §§261.5(f)(2) and (g)(2)	≤6,000 kg §262.34(d)(1)	No limit
Accumulation Time Limits	None §261.5	≤180 days or ≤270 days (if greater than 200 miles) §§262.34(d)(2) and (3)	≤90 days §262.34(a)

	CESQGs	SQGs	LQGs
Storage Requirements	None §261.5	Basic requirements with technical standards for tanks or containers §§262.34(d)(2) and (3)	Full compliance for management of tanks, containers, drip pads, or containment buildings §262.34(a)
Sent To:	State approved or RCRA permitted/interim status facility §§261.5(f)(3) and (g)(3)	RCRA permitted/interim status facility §262.20(b)	RCRA permitted/interim status facility §262.20(b)
Manifest	Not required §261.5	Required §262.20	Required §262.20
Biennial Report	Not required §261.5	Not required §262.44	Required §262.41
Personnel Training	Not required §261.5	Basic training required §262.34(d)(5)(iii)	Required §262.34(a)(4)
Contingency Plan	Not required §261.5	Basic plan §262.34(d)(5)(i)	Full plan required §262.34(a)(4)
Emergency Procedures	Not required §261.5	Required §262.34(d)(5)(iv)	Full plan required §262.34(a)(4)
DOT Transport Requirements	Yes (if required by DOT)	Yes §§262.30-262.33	Yes §§262.30-262.33

5.5 Onsite IDW Management Procedures

Onsite handling procedures typically involve containerization of the IDW for offsite disposal at a regulated facility (RCRA hazardous waste, TSCA PCB waste, or certain non-hazardous wastes) or, in the case of certain non-hazardous wastes, onsite disposal. The procedures for each type of waste are presented below.

5.5.1 Hazardous Waste Management

If site data or generator knowledge indicates that the IDW is determined to be RCRA hazardous, the following procedures will apply:

- Place IDW in DOT-authorized containers (e.g., 55-gallon drum, roll-off container, or temporary storage tank). Before placing IDW in the containers, ensure that they are in good condition and will not leak.
- Containers must remain closed except when adding, sampling, or inspecting the material. The containers cannot be used as a work surface once waste is put in the container.
- Mark the container with an appropriate waterproof, self-adhesive RCRA hazardous waste label. The label must include the accumulation start date, a description of the contents of the container (e.g., soil cuttings, purge water, etc.), the EPA identification number, the generator name (the client or the facility, never WSP), and the

hazardous waste codes, if known. Field personnel must consult the assigned WSP compliance professional for help in properly completing the labels.

- The IDW containers must be properly closed, wiped clean, and stored in a secure onsite location (facility hazardous waste storage area if one exists) to limit access. At a minimum, place the drums on an impermeable surface (if available) in an area of limited access. If stored outside, cover the containers with a secured tarp at the end of each field day until the containers are picked up for disposal.
- Complete the IDW Logs (Figure 1) before leaving the site. Present one copy of the log to the site contact and the original to the project manager.
- Ensure that weekly inspections are conducted and the proper inspection forms for documentation are completed during the entire time the waste is stored onsite.

If the IDW is presumed to be hazardous and sampling is required to confirm its classification, it must be labeled “Hazardous Waste-Pending Analysis” and sampled for the parameters specified by the project regulatory specialist or project manager before leaving the site (see sampling SOPs). Treatment, storage, and disposal facilities will usually specify the required analysis for waste profiles (see below).

5.5.2 Polychlorinated Biphenyl Waste Management

If information exists to classify the IDW as TSCA-regulated PCB-containing IDW, the following procedures must be implemented:

- Place the PCB-containing IDW in DOT-authorized containers (55-gallon drum, roll-off container, or temporary storage tank).
- Containers must remain closed except when adding, sampling, or inspecting the material. The containers cannot be used as a work surface once waste is put in the container.
- Mark the container with an appropriate waterproof, self-adhesive yellow label with the words “Caution Contains PCBs”, the “removed from service” date (the accumulation start date), and a description of the contents of the container (e.g., soil cuttings). Complete the label with the name and phone number of the WSP field personnel to contact in the event of an accident or spill. Field personnel must consult the assigned WSP compliance professional for help in properly completing the labels.
- The IDW containers must be properly closed, wiped clean, and stored in a secure PCB storage area onsite. If a PCB storage area is not available, construct a temporary PCB storage area. Cover the containers with a secured tarp at the end of each field day until the drums are picked up for disposal. Place one yellow 6” x 6” “Caution Contains PCBs” label on the outside of the tarp, and note the “Removed from service date” on the label.
- Inspect the area and the containers for leaks once every 30 days in accordance with 40 Code of Federal Regulations 761.65(c)(5) during the entire period the waste is stored onsite.
- Complete the IDW Logs (Figure 1) before leaving the site. Present one copy of the log to the site contact and the original to the project manager.

5.5.3 Onsite Non-Hazardous Waste Management

If information exists to classify the IDW as non-hazardous waste, the following procedures must be implemented only after being discussed and approved by the project manager and assigned WSP compliance professional:

- Soil can be spread around the borehole or other onsite location (with the approval of the client and in accordance with any applicable regulatory requirements), placed back in the boring or excavated test pit, or containerized and disposed of offsite.

- Groundwater and decontamination fluids can be poured onto the ground next to well to allow infiltration, or discharged to either the publically-owned treatment works or onsite wastewater treatment plant with approval of the client.
- PPE can be double bagged and deposited in the site dumpster with approval of the client and facility personnel or containerized and disposed of offsite.

If the IDW is containerized and is classified as non-hazardous, the following procedures will apply:

- Place the non-hazardous IDW in DOT-authorized containers (55-gallon drum, roll-off container, or temporary storage tank).
- Containers must remain closed except when adding, sampling, or inspecting the material. The containers cannot be used as a work surface once waste is put in the container.
- Mark the container with an appropriate waterproof, self-adhesive non-hazardous waste label. The label must include a description of the contents of the container (e.g., soil cuttings, purge water, etc.) and the generator (the client or the facility, never WSP). Field personnel must consult the assigned WSP compliance professional for help in properly completing the labels.
- Complete the IDW Logs (Figure 1) before leaving the site. Present one copy of the log to the site contact and the original to the project manager.
- The IDW containers must be properly closed, wiped clean, and stored in a secure onsite location.

5.6 Post-Field IDW Management Activities

It is important to follow-up on the management of the IDW once the field personnel have returned from the field. RCRA Hazardous and TSCA-regulated PCB-containing wastes have time limits and periodic inspection requirements to remain in compliance with state and federal regulations. The general post-field activities are listed below.

5.6.1 Waste Classification and Waste Profiles

Waste classifications and waste profiles must be reviewed and approved by WSP's project manager, WSP compliance professional, and the client before field work begins. Waste profiles are generated based on new or existing site data (i.e., soil and groundwater results) and generator knowledge, although some disposal facilities may require additional composite or grab samples for characterization of the waste. WSP's compliance professionals must be consulted to verify that proper waste classifications have been identified. Waste profiles for the same waste stream are generally valid for one year; ensure that no additional sampling is required to update existing waste profiles before conducting field activities.

5.6.2 Waste Disposal Oversight

Although exceptions may apply, generally, disposal of RCRA hazardous must be completed within **90 days** of the accumulation start date. If the facility is a small quantity generator, up to **180 days** is allowed for shipment. Disposal of TSCA-regulated PCB-containing IDW must generally be completed within 30 days of the "removal of service" date. WSP's compliance professionals must be consulted to determine if any exemptions apply.

Before the IDW is removed, the waste disposal subcontractor must provide WSP with a copy of the waste profile and printed manifest for review and approval. Your assigned WSP compliance professional must review and approve these documents. WSP must have written authorization from the client on file to act **on behalf of (never "as an agent of")** the client for waste disposal (handled on a site-by-site basis).

- The transport driver will present you with a pre-printed manifest that has been reviewed and approved by WSP. Review and verify that all information is complete and correct and that the total estimated weight of the material is written on the manifest. (Note: Manifests for PCB wastes must be completed in accordance with TSCA regulations. 40 CFR 761.207 requires that the weight of the PCBs be in kilograms and the date removed from service be on the manifest.) Remember, only a DOT-trained WSP employee is allowed to review and sign the manifest.
- Sign the manifest “On behalf of [insert client name].” Do not us “as an agent of.”
- Ensure that all containers are properly labeled and transferred to the transporting vehicle; ensure that the vehicle is properly placarded.
- Once the IDW has been removed from the site, the IDW log must be marked “Removed,” placed in the project file, and a copy must be forwarded to WSP’s DOT compliance manager.

The manifest, certificate of disposal, IDW log, and inspection reports must be maintained on file for at least 3 years.

Investigation Derived Waste Log

Date:_______________

Site Information

Site Name: __________________________________ Site EPA ID #:______________________________

Site Contact: __________________________________ Site Address: ______________________________

Contact Telephone No: ___________________________

Waste Identification:

Type of Waste Generated (check one of the following):

☐ Soil Cuttings ☐ PPE ☐ Decontamination Water

☐ Groundwater ☐ Storm Water ☐ Drilling Fluids

☐ Other (Describe):____

Field Activities that Generated the Waste:

☐ Soil Borings ☐ Well Sampling ☐ Well Installation

☐ Decon ☐ Excavation ☐ Pumping Tests

☐ Other (Describe): ____

Generation Date:__________________________ ***90-Day Deadline***: _____________________________

Quantity of Waste Generated and Container Type:

____

____

Storage Location:____

Waste Identification (Check One of the Following):

☐ Non Hazardous Waste (pending analysis)

☐ Non Hazardous Waste (based on site information or generator knowledge)

☐ Hazardous Waste (pending analysis)

☐ Hazardous Waste (based on site information or generator knowledge)

If generator knowledge or site information was used for identification, explain: ________________________

____

____

Type of Label Applied to Container: ☐ Non Haz ☐ Hazardous ☐ PCB ☐ Used Oil

WSP Information (Note: One copy to site contact - the original in project file)

Personnel/Contact:____________________________________ Project No.: ________________________

Telephone:____

FIELD STANDARD OPERATING PROCEDURE #7
Water Quality Monitoring Equipment Procedure

The procedures outlined in this Standard Operating Procedure (SOP) are designed to ensure that water quality monitoring equipment is calibrated and used properly. This SOP addresses the short-term or discrete-measurement use of portable water quality monitoring equipment for the collection of physical, chemical, or biological field measurements. Common field parameters include temperature, pH, specific conductance (SC), turbidity, oxidation-reduction potential (ORP), and dissolved oxygen (DO). The user is advised to read the entire SOP and review the site health and safety plan (HASP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

7.1 Acronyms and Abbreviations

DI	deionized water
DO	dissolved oxygen
^{o}F	degrees Fahrenheit
HASP	health and safety plan
IDW	investigation derived waste
mg/l	milligrams per liter
mV	millivolts
NTU	nephelometric turbidity units
ORP	oxidation-reduction potential
PPE	personal protective equipment
QAPP	quality assurance project plan
SC	specific conductance
SDS	Safety Data Sheets
SOP	standard operating procedure
SU	standard units
µS/cm	microsiemens per centimeter

7.2 Materials

- Field book
- PPE
- Water quality meter
- Display/logger
- Communication cables
- Calibration cup or beaker
- Standard solutions, as appropriate

- Deionized water (DI) or distilled water
- Decontamination supplies

7.3 Preconditions and Background

This SOP has been prepared as part of the WSP USA Corp. Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of WSP employees and will be revised periodically to reflect updates to WSP policies, work practices, and the applicable state and/or federal guidance. WSP employees must verify that this document is the most recent version of the WSP SOPs. WSP employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

This SOP is designed to provide the user with a general outline for preparing water quality monitoring equipment for use and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), investigation derived waste (IDW) management procedures (SOP 5), equipment decontamination (SOP 6), groundwater sampling (SOP 11), and surface water sampling (SOP 12). This SOP does not cover the selection of water quality monitoring equipment, nor does it cover water quality monitoring equipment-specific instructions. These topics require a significant amount of planning and are more appropriately addressed in a project-specific work plan. Be sure to review the project-specific work plan or Quality Assurance Project Plan (QAPP) and any applicable state and federal guidelines or calibration procedures. The sampler should be familiar with the use and calibration of all sampling and monitoring equipment. All sampling references must be available for consultation in the field, including:

- WSP's SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer's manuals
- Project-specific work plan, HASP, and QAPP

7.4 General Equipment Handling and Management Procedures

Generally, WSP uses multi-parameter water quality meters bundled in a single housing unit (a sonde). These types of units offer a single, convenient device that is capable of measuring most or all of the parameters monitored during a typical sampling event. Individual parameter water quality meters are available and, in some cases, offer a higher degree of accuracy, although the difficulty in deploying multiple meters for most tasks relegates them to specialty use.

Field personnel must consult their assigned WSP compliance professionals for assistance in proper use, storage, and disposal of all calibration standard solutions.

The manufacturer's recommendations and instructions vary from one instrument to the next; however, all types of water quality monitoring equipment share common handling and management procedures designed to ensure the integrity of the measurements collected. Based on these procedures, the user should:

- Transport the water quality monitoring equipment in a padded case that is designed to protect the equipment; airtight cases need to be vented if using sensors that have flexible or semi-permeable membranes.
- Follow the manufacturer's instructions for assembly, operation, calibration, and maintenance specific to your equipment. The manufacturer's instructions should be followed explicitly in order to obtain accurate results.

- Follow the manufacturer’s instructions for assembly, operation, calibration, and maintenance specific to your equipment. The manufacturer’s instructions should be followed explicitly in order to obtain accurate results.
- Keep either the sensor guard or transportation/calibration cup installed to avoid damaging the sensors. Some sensors require a small amount of water in the transportation/calibration cup; follow the manufacturer’s recommendations.
- Ensure that all equipment is in proper working condition, not damaged, and that batteries are properly charged before using the equipment for field testing measurements.
- Instruments may be sensitive to static electricity.
- Record manufacturer name and model number for each instrument used in the field book.
- Calibrate the instrument in the field, as close to the time of use as possible, and repeat at the frequency suggested by the manufacturer.
- Protect the instrument from direct sunlight, precipitation, and extremely hot or cold temperatures (e.g., do not store in vehicle).
- Store cables only after they are clean, dry, and neatly coiled – do not bend or crimp cables.
- Attach any provided storage caps. Protect cables from abrasion or unnecessary tension when in use.
- Unless otherwise instructed by the manufacturer, decontaminate water quality monitoring equipment with non-phosphate detergent solution using a small, nonabrasive brush, cotton swab or cloth, followed by a thorough DI water rinse.

7.5 Calibration Procedures

Water quality monitoring equipment must be inspected and the sensors calibrated before use. Consult the manufacturer’s guidelines before beginning the calibration process and contact the manufacturer’s technical support if problems or questions arise.

Conduct the following procedures to ensure proper testing and calibration and record observations in the field book:

- Inspect the sensors to be sure that they are clean, installed properly and are not damaged before calibrating and using a water quality monitoring equipment in the field.
- Complete field calibration in an area sheltered from wind, dust, and temperature/sunlight fluctuations such as inside a room or vehicle in which the ambient temperature of the standards is maintained at a temperature >40 degrees Fahrenheit (^{o}F) and < 100°F.
- Purchase appropriate, prepared standard solutions in accordance with the project-specific work plan or QAPP. Do not mix or dilute standards in the field. Allow water quality monitoring equipment to warm up for at least 10 minutes after being turned on, or for the specified time period recommended by the manufacturer.
- Record the brand, concentration, lot numbers and expiration dates of standard solutions in the field book.
- Handle standard solutions in a manner that prevents their dilution or contamination. Do not use expired standard solutions. Do not reuse standard solutions or pour solutions back into the bottle; ensure that proper chain-of-custody has been followed for standard solutions stored at a site.
- Ensure that the water quality monitoring equipment has been set to display or record the appropriate measurement unit, as available.
- Allow standard solutions to equilibrate to the temperature of the sample source, to the degree possible or as specified in the manufacturer’s guidance.

- Unless otherwise instructed by the manufacturer, use the calibration cup that comes with the instrument for calibration.
- Use the recommended volume of standard solution when filling the calibration cup (e.g., the standard solution must cover the temperature sensor, as most sensors require temperature compensation).
- Be careful not to over tighten the calibration cup; many calibration cups have vents that allow their equilibration with ambient pressure.
- Rinse sensors thoroughly three times with DI water after use of each standard solution, followed by three rinses with the next standard solution to be used.
- Wait for readings to stabilize (approximately 30 seconds under normal conditions) before adjusting and saving the calibration point.
- Do not override a calibration error message without troubleshooting and correcting the cause of the error. For example, check the fluid level and check for air bubbles in the sensor. Record calibration end points and readings in the field book.
- Calibration frequency is dependent upon project specifications, instrument performance, and manufacturer's recommendations; repeat the calibration procedures as directed.
- Document the time, date, and calibration status for each instrument.
- If calibration fails to meet criteria, follow the manufacturer's instructions for corrective action to adjust instrument performance and note any indication of a substandard calibration.
- If the instrument does not start up, check out, or calibrate properly, the instrument should not be used.

7.5.1 Specific Conductance

SC, or conductivity, measures the ability of water to conduct an electric current. It is generally reported in microsiemens per centimeter (µS/cm) or millisiemens per centimeter. Natural waters, including groundwater, commonly exhibit specific conductance well below 1 µS/cm. Total dissolved solid concentrations may be approximated from specific conductance data; high readings (greater than 500 µS/cm) may indicate contamination, especially if the readings are elevated compared to background. Alternatively, elevated specific conductance may indicate inadequate well development, grout contamination, or an inadequate grout seal.

When calibrating for specific conductance:

- If not specified in the project-specific work plan, choose a SC standard solution recommended by the instrument manufacturer; otherwise, select a standard that is close in conductivity to that of the environmental water being sampled.
- The presence of air bubbles in conductivity electrodes will cause erroneous readings and incorrect calibration. Transmission lines, alternating-current electrical outlets and radio-frequency noise sources may cause interference; check with the instrument manufacturer's specifications for troubleshooting procedures.

7.5.2 Dissolved Oxygen

DO is used to assess the water quality with respect to certain metals (the amount of oxygen can control the valence state of metals) and, more typically, biological activity. Concentrations of DO in uncontaminated groundwater generally range from 1 to 4 milligrams per liter (mg/l). Erratic or elevated (greater than 4 milligrams per liter) DO readings may reflect sampling procedures that are causing excessive agitation and aeration of the water column which may affect sample results (i.e., oxidation or volatilization of dissolved compounds). Elevated DO readings may also indicate equipment maintenance issues. DO readings are sensitive to atmospheric interference and must be measured with a flow-through cell for *ex situ* measurements (i.e., those measured outside of the well itself). Select the type of DO sensor for the multi-parameter water quality meter in accordance with the project-specific work plan (i.e., the polarographic [or Clark cell] sensor or the luminescent [optical] sensor). Further discussion focuses on the more common polarographic sensor.

- Check the DO membrane for bubbles, wrinkles or tears. If necessary, install a new membrane and replace worn or stretched O-rings. Manufacturer guidance generally specifies membrane replacement should be completed at least 3 to 4 hours before use,
- Most manufacturers recommend that the sensor be allowed to equilibrate to the temperature of the water-vapor-saturated air for at least 15 minutes before calibration,
- Fill the calibration cup with less than 1/8 inch of water, or as recommended by the manufacturer.
- Remove any water droplets from the sensor without wiping the membrane. Water droplets on the sensor can cause a temperature compensation error in the DO calibration.
- Do not submerge or wet the sensor when loosely attaching the calibration cup.
- Enter the barometric pressure and wait for readings to stabilize before adjusting and saving the calibration point.

7.5.3 pH

pH is a measure of the effective concentration (or activity) of hydrogen ions and is expressed as the negative base-10 logarithm of the hydrogen-ion activity in moles per liter. Natural (uncontaminated) waters typically exhibit a pH ranging from 5 to 9 Standard Units (SU). Deviation of pH from background may indicate the presence of groundwater contamination or well construction problems.

Typically, a two-point calibration is used for pH (i.e., a zero-point and span calibration[s]):

- If not specified in the project-specific work plan, select a 7 SU buffer (zero-point) plus a second pH buffer (4 SU or 10 SU) that brackets the range of expected pH.
- If applicable, calibrate the conductivity and DO sensors before calibrating the pH sensor. This helps prevent cross-contamination of the conductivity sensor from pH buffer solutions (pH buffers have much higher conductivities than most environmental waters).
- Allow time for the pH and temperature sensors to equilibrate to the temperature of the buffer and stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the buffer manufacturer to determine the true pH of the buffer at that temperature and adjust the calibration reading to that value.
- Repeat the calibration process with the second buffer.

7.5.4 Oxidation-Reduction Potential

ORP is a numerical index of the intensity of the oxidizing or reducing conditions within an aqueous solution. Oxidizing conditions are indicated by positive potentials and reducing conditions are indicated by negative potentials; these values are frequently used when evaluating the biodegradation capacity of a system. Generally, negative potentials and low DO (less than 1 mg/l) are measured concurrently. ORP measurements are generally expressed in millivolts (mV). The ORP of natural (uncontaminated) waters typically ranges from +500 to -100 mV. ORP and reduction potential (Eh) are not equivalent. Follow the manufacturer’s instructions to calculate Eh. ORP readings are sensitive to atmospheric interference and must be measured with a flow-through cell; ORP may not be an appropriate stabilization parameter for some groundwater conditions. Avoid touching the sensors during calibration and measurement as calibration can be affected by static electricity.

A one-point calibration, at a known temperature, is used to calibrate the ORP sensor:

- Fill the calibration cup with enough standard solution (i.e., ZoBell's solution) to completely cover the temperature and ORP sensors.
- Allow time for the ORP and temperature sensors to equilibrate to the temperature of the buffer and stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the manufacturer to determine the true ORP of the solution at that temperature and adjust the calibration reading to that value.

7.5.5 Turbidity

Turbidity is the presence of suspended mineral and organic particles in a water sample. Turbid water may indicate inadequate well construction, development or improper sampling procedures, such as purging at an excessive rate that exceeds the well yield. Purging and sampling in a manner that produces low-turbidity water is particularly important when analyzing for total metals and other hydrophobic compounds, such as polychlorinated biphenyls, which may exhibit artificially elevated concentrations in high-turbidity samples due to their adsorption to colloidal material. Generally, the turbidity of *in situ* groundwater is very low (at or below 10 nephelometric turbidity units, NTUs); however, some groundwater zones may have natural turbidity higher than 10 NTUs.

Standard turbidity solutions are not necessarily interchangeable. Serious calibration errors can result from using inappropriate standards. Use only those standard turbidity solutions that are prescribed for the sensor by the instrument manufacturer.

Turbidity consists of a zero-point calibration and a span calibration(s):

- Fill the calibration cup to the reference line with DI or a zero-point standard.
- Allow time for the turbidity sensors to stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the buffer manufacturer to determine the true turbidity of the buffer and adjust the calibration reading to that value.
- Repeat the calibration process with the standard span calibration standard(s).

7.6 Equipment Use Procedures

Following calibration, use the monitoring equipment to complete the field measurement procedures directed in the project-specific work plan or QAPP.

- Charge instrument batteries per the manufacturer's instructions, as necessary.
- Ensure that instrument is warmed up and the measured value(s) on the water quality monitoring equipment are equilibrated (i.e., readings are representative of the solution, not ambient air) before recording in the field book.
- Biological growth or debris in the water can foul sensors; as possible, avoid inserting the sonde in areas that will result in having to stop and clean algae, sediment, or debris from the sensors (e.g., do not place on bottom of a well or streambed).
- If continuous monitoring is required, follow the manufacturer's instructions for performing continuous data logging events.

Monitoring should be performed at regular intervals as specified in the work plan, QAPP, and/or HASP. Record all measurements in the field book or on field forms and note any conditions that may affect the quality of the data (e.g., changes in weather or background conditions).

7.6.1 Groundwater

Field parameters are generally measured *ex situ* during well purging and development to provide an indication of when water representative of the formation is entering the well. Field parameters are typically recorded after each well volume is purged or at a periodic interval until stability criteria have been met. Field parameters may be measured *in situ* during purging by deploying a multi-parameter water quality meter downhole or lowered into a well or piezometer and collected at various depths (i.e., depth profile). Follow the instructions detailed in SOP 11 (Groundwater Sampling Procedures) for groundwater purging and sampling procedures.

7.6.1.1 Flow-through Cell Operation

A flow-through cell is used to minimize potential alteration of the water during contact with the air. A flow-through cell must be used when measuring DO or ORP under *ex situ* conditions*.*

- Inspect the integrity of the flow-through cell and O-rings.
- Connect the discharge tubing to the bottom of the flow-through cell using properly-sized tubing and fittings. Connect the effluent tubing to the top of the flow-through cell and secure the end of the tubing into the designated groundwater purge container.
- Shield the flow-through cell from direct sunlight to minimize changes in the temperature.
- Do not record any measurements until all the air from the flow-through cell and the effluent tubing has been displaced and the sensors have equilibrated. The presence of air bubbles in the flow-through cell will result in highly biased readings. <u>Do not</u> collect groundwater samples for laboratory analysis from the groundwater in the flow-through cell.

7.6.2 Surface Water

Surface water quality measurements commonly are monitored within a cross section of the surface water body to help determine the level of stratification or mixing (if the water body is moving). Typically a multi-parameter water quality meter is lowered through the water column to collect the data *in situ*. A multi-parameter water quality meter may be paired with a pressure transducer or graduated cable to record water quality changes with depth (i.e., depth profile). If strong currents exist, it may be necessary to attach the instruments to a weighted rope. After recording multiple measurements, as possible, return to the original measurement location to confirm the initial measurement; repeat as necessary. Follow the instructions detailed in SOP 12 (Surface Water Sampling Procedures) for surface water sampling procedures.

7.7 Closing Notes

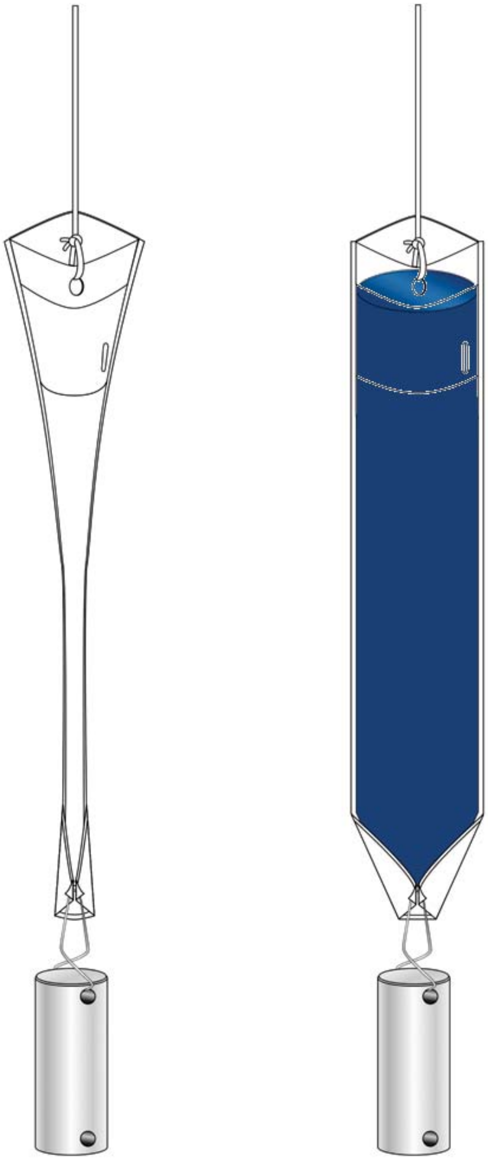
Once field activities are complete, secure the site in accordance with the project-specific work plan. Decontaminate all equipment prior to departure and properly manage all PPE and IDW in conformance with applicable regulations.

Appendix C – HydraSleeve Standard Operating Procedure

HYDRASleeve™

Simple by Design US Patent No. 6,481,300; No. 6,837,120 others pending

Standard Operating Procedure: Sampling Ground Water with a HydraSleeve



This Guide should be used in addition to field manuals appropriate to sampling device (i.e., HydraSleeve or Super Sleeve).

Find the appropriate field manual on the HydraSleeve website at http://www.hydrasleeve.com.

For more information about the HydraSleeve, or if you have questions, contact:
GeoInsight, 2007 Glass Road, Las Cruces, NM 88005, 1-800-996-2225,
info@hydrasleeve.com.

Table of Contents

Introduction

The HydraSleeve is classified as a no-purge (passive) grab sampling device, meaning that it is used to collect ground-water samples directly from the screened interval of a well without having to purge the well prior to sample collection. When it is used as described in this Standard Operating Procedure (SOP), the HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the screen only, and it excludes water from any other part of the water column in the well through the use of a self-sealing check valve at the top of the sampler. It is a single-use (disposable) sampler that is not intended for reuse, so there are no decontamination requirements for the sampler itself.

The use of no-purge sampling as a means of collecting representative ground-water samples depends on the natural movement of ground water (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non-pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005).

Applications of the HydraSleeve

The HydraSleeve can be used to collect representative samples of ground water for all analytes (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], common metals, trace metals, major cations and anions, dissolved gases, total dissolved solids, radionuclides, pesticides, PCBs, explosive compounds, and all other analytical parameters). Designs are available to collect samples from wells from 1” inside diameter and larger. The HydraSleeve can collect samples from wells of any yield, but it is especially well-suited to collecting samples from low-yield wells, where other sampling methods can’t be used reliably because their use results in dewatering of the well screen and alteration of sample chemistry (McAlary and Barker, 1987).

The HydraSleeve can collect samples from wells of any depth, and it can be used for single-event sampling or long-term ground-water monitoring programs. Because of its thin cross section and flexible construction, it can be used in narrow, constricted or damaged wells where rigid sampling devices may not fit. Using multiple HydraSleeves deployed in series along a single suspension line or tether, it is also possible to conduct in-well vertical profiling in wells in which contaminant concentrations are thought to be stratified.

As with all groundwater sampling devices, HydraSleeves should not be used to collect groundwater samples from wells in which separate (non-aqueous) phase hydrocarbons (i.e., gasoline, diesel fuel or jet fuel) are present because of the possibility of incorporating some of the separate-phase hydrocarbon into the sample.

Description of the HydraSleeve

The HydraSleeve (Figure 1) consists of the following basic components:

- A suspension line or tether (A.), attached to the spring clip or directly to the top of the sleeve to deploy the device into and recover the device from the well. Tethers with depth indicators marked in 1-foot intervals are available from the manufacturer.
- A long, flexible, 4-mil thick lay-flat polyethylene sample sleeve (C.) sealed at the bottom (this is the sample chamber), which comes in different sizes, as discussed below with a self-sealing reed-type flexible polyethylene check valve built into the top of the sleeve (B.) to prevent water from entering or exiting the sampler except during sample acquisition.
- A reusable stainless-steel weight with clip (D.), which is attached to the bottom of the sleeve to carry it down the well to its intended depth in the water column. Bottom weights available from the manufacturer are 0.75” OD and are available in three sizes: 5 oz. (2.5” long); 8 oz. (4” long); and 16 oz. (8” long). In lieu of a bottom weight, an optional top weight may be attached to the top of the HydraSleeve to carry it to depth and to compress it at the bottom of the well (not shown in Figure 1);
- A discharge tube that is used to puncture the HydraSleeve after it is recovered from the well so the sample can be decanted into sample bottles (not shown).
- Just above the self-sealing check valve at the top of the sleeve are two holes which provide attachment points for the spring clip and/or suspension line or tether. At the bottom of the sample sleeve are two holes which provide attachment points for the weight clip and weight.

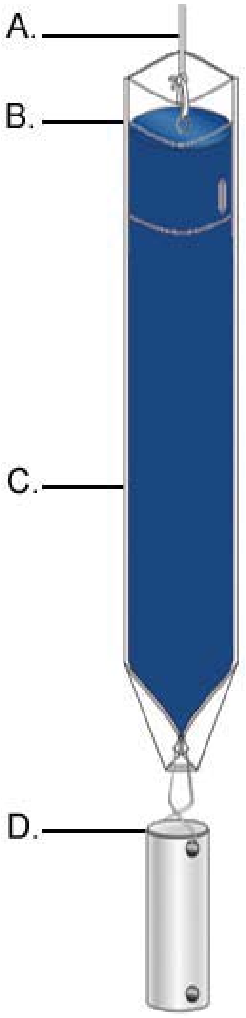


Figure 1. HydraSleeve components.

Note: The sample sleeve and the discharge tube are designed for one-time use and are disposable. The spring clip, weight and weight clip may be reused after thorough cleaning. Suspension cord is generally disposed after one use although, if it is dedicated to the well, it may be reused at the discretion of the sampling personnel.

Selecting the HydraSleeve Size to Meet Site-Specific Sampling Objectives

It is important to understand that each HydraSleeve is able to collect a finite volume of sample because, after the HydraSleeve is deployed, you only get one chance to collect an undisturbed sample. Thus, the volume of sample required to meet your site-specific sampling and analytical requirements will dictate the size of HydraSleeve you need to meet these requirements.

The volume of sample collected by the HydraSleeve varies with the diameter and length of the HydraSleeve. Dimensions and volumes of available HydraSleeve models are detailed in Table 1.

Table 1. Dimensions and volumes of HydraSleeve models.

Diameter	Volume	Length	Lay-Flat Width	Filled Dia.
2-Inch HydraSleeves				
Standard 625-ml HydraSleeve	625 ml	< 30”	2.5”	1.4”
Standard 1-Liter HydraSleeve	1 Liter	38”	3”	1.9”
1-Liter HydraSleeve SS	1 Liter	36”	3”	1.9”
2-Liter HydraSleeve SS	2 Liters	60”	3”	1.9”
4-Inch HydraSleeves				
Standard 1.6-Liter HydraSleeve	1.6 Liters	30”	3.8”	2.3”
Custom 2-Liter HydraSleeve	2 Liters	36”	4”	2.7”

HydraSleeves can be custom-fabricated by the manufacturer in varying diameters and lengths to meet specific volume requirements. HydraSleeves can also be deployed in series (i.e., multiple HydraSleeves attached to one tether) to collect additional sample to meet specific volume requirements, as described below.

If you have questions regarding the availability of sufficient volume of sample to satisfy laboratory requirements for analysis, it is recommended that you contact the laboratory to discuss the minimum volumes needed for each suite of analytes. Laboratories often require only 10% to 25% of the volume they specify to complete analysis for specific suites of analytes, so they can often work with much smaller sample volumes that can easily be supplied by a HydraSleeve.

HydraSleeve Deployment

Information Required Before Deploying a HydraSleeve

Before installing a HydraSleeve in any well, you will need to know the following:

- The inside diameter of the well
- The length of the well screen
- The water level in the well
- The position of the well screen in the well
- The total depth of the well

The inside diameter of the well is used to determine the appropriate HydraSleeve diameter for use in the well. The other information is used to determine the proper placement of the HydraSleeve in the well to collect a representative sample from the screen (see HydraSleeve Placement, below), and to determine the appropriate length of tether to attach to the HydraSleeve to deploy it at the appropriate position in the well.

Most of this information (with the exception of the water level) should be available from the well log; if not, it will have to be collected by some other means. The inside diameter of the well can be measured at the top of the well casing, and the total depth of the well can be measured by sounding the bottom of the well with a weighted tape. The position and length of the well screen may have to be determined using a down-hole camera if a well log is not available. The water level in the well can be measured using any commonly available water-level gauge.

HydraSleeve Placement

The HydraSleeve is designed to collect a sample directly from the well screen, and it fills by pulling it up through the screen a distance equivalent to 1 to 1.5 times its length. This upward motion causes the top check valve to open, which allows the device to fill. To optimize sample recovery, it is recommended that the HydraSleeve be placed in the well so that the bottom weight rests on the bottom of the well and the top of the HydraSleeve is as close to the bottom of the well screen as possible. This should allow the sampler to fill before the top of the device reaches the top of the screen as it is pulled up through the water column, and ensure that only water from the screen is collected as the sample. In short-screen wells, or wells with a short water column, it may be necessary to use a top-weight on the HydraSleeve to compress it in the bottom of the well so that, when it is recovered, it has room to fill before it reaches the top of the screen.

Example

2” ID PVC well, 50’ total depth, 10’ screen at the bottom of the well, with water level above the screen (the entire screen contains water).

Correct Placement (figure 2): Using a standard HydraSleeve for a 2” well (2.6” flat width/1.5” filled OD x 30” long, 650 ml volume), deploy the sampler so the weight (an 8 oz., 4”-long weight with a 2”-long clip) rests at the bottom of the well. The top of the sleeve is thus set at about 36” above the bottom of the well. When the sampler is recovered, it will be pulled upward approximately 30” to 45” before it is filled; therefore, it is full (and the top check valve closes) at approximately 66” (5 ½ feet) to 81” (6 ¾ feet) above the bottom of the well, which is well before the sampler reaches the top of the screen. In this example, only water from the screen is collected as a sample.

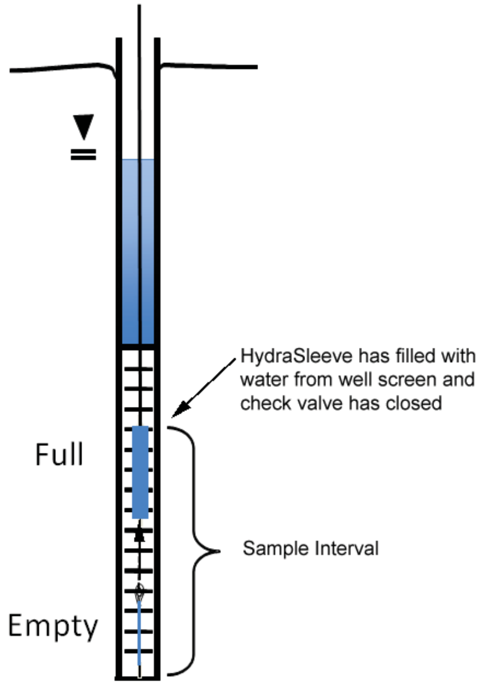


Figure 2. Correct placement of HydraSleeve.

Incorrect Placement (figure 3): If the well screen in this example was only 5' long, and the HydraSleeve was placed as above, it would not fill before the top of the device reached the top of the well screen, so the sample would include water from above the screen, which may not have the same chemistry.

The solution? Deploy the HydraSleeve with a top weight, so that it is collapsed to within 6" to 9" of the bottom of the well. When the HydraSleeve is recovered, it will fill within 39" (3 ¼ feet) to 54" (4 ½ feet) above the bottom of the well, or just before the sampler reaches the top of the screen, so it collects only water from the screen as the sample.

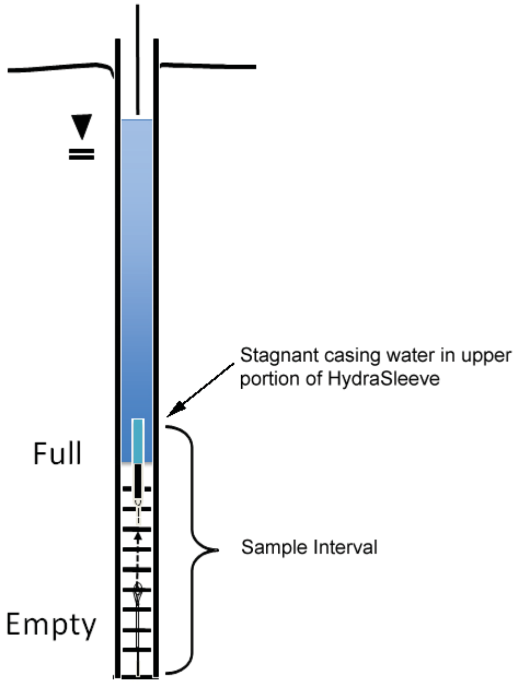


Figure 3. Incorrect placement of HydraSleeve.

This example illustrates one of many types of HydraSleeve placements. More complex placements are discussed in a later section.

Procedures for Sampling with the HydraSleeve

Collecting a ground-water sample with a HydraSleeve is a simple one-person operation.

Note: Before deploying the HydraSleeve in the well, collect the depth-to-water measurement that you will use to determine the preferred position of the HydraSleeve in the well. This measurement may also be used with measurements from other wells to create a ground-water contour map. If necessary, also measure the depth to the bottom of the well to verify actual well depth to confirm your decision on placement of the HydraSleeve in the water column.

Measure the correct amount of tether needed to suspend the HydraSleeve in the well so that the weight will rest on the bottom of the well (or at your preferred position in the well). Make sure to account for the need to leave a few feet of tether at the top of the well to allow recovery of the sleeve

Note: Always wear sterile gloves when handling and discharging the HydraSleeve.

I. Assembling the HydraSleeve

1. Remove the HydraSleeve from its packaging, unfold it, and hold it by its top.

2. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.

3. Attach the spring clip to the holes to ensure that the top will remain open until the sampler is retrieved.

4. Attach the tether to the spring clip by tying a knot in the tether.

Note: Alternatively, attach the tether to one (NOT both) of the holes at the top of the Hydrasleeve by tying a knot in the tether.

5. Fold the flaps with the two holes at the bottom of the HydraSleeve together and slide the weight clip through the holes.

6. Attach a weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the bottom of the well.

II. Deploying the HydraSleeve

1. Using the tether, carefully lower the HydraSleeve to the bottom of the well, or to your preferred depth in the water column

   During installation, hydrostatic pressure in the water column will keep the self-sealing check valve at the top of the HydraSleeve closed, and ensure that it retains its flat, empty profile for an indefinite period prior to recovery.

Note: Make sure that it is not pulled upward at any time during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5'/second at any time prior to recovery, the top check valve will open and water will enter the HydraSleeve prematurely.

2. Secure the tether at the top of the well by placing the well cap on the top of the well casing and over the tether.

Note: Alternatively, you can tie the tether to a hook on the bottom of the well cap (you will need to leave a few inches of slack in the line to avoid pulling the sampler up as the cap is removed at the next sampling event).

III. Equilibrating the Well

The equilibration time is the time it takes for conditions in the water column (primarily flow dynamics and contaminant distribution) to restabilize after vertical mixing occurs (caused by installation of a sampling device in the well).

- Situation: The HydraSleeve is deployed for the first time or for only one time in a well

  The HydraSleeve is very thin in cross section and displaces very little water (<100 ml) during deployment so, unlike most other sampling devices, it does not disturb the water column to the point at which long equilibration times are necessary to ensure recovery of a representative sample.

  In most cases, the HydraSleeve can be recovered immediately (with no equilibration time) or within a few hours. In regulatory jurisdictions that impose specific requirements for equilibration times prior to recovery of no-purge sampling devices, these requirements should be followed.

- Situation: The HydraSleeve is being deployed for recovery during a future sampling event

  In periodic (i.e., quarterly or semi-annual) sampling programs, the sampler for the current sampling event can be recovered and a new sampler (for the next sampling event) deployed immediately thereafter, so the new sampler remains in the well until the next sampling event.

Thus, a long equilibration time is ensured and, at the next sampling event, the sampler can be recovered immediately. This means that separate mobilizations, to deploy and then to recover the sampler, are not required. HydraSleeves can be left in a well for an indefinite period of time without concern.

IV. HydraSleeve Recovery and Sample Collection

1. Hold on to the tether while removing the well cap.

2. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards)

3. Measure the water level in the well.

4. In one smooth motion, pull the tether up between 30” to 45” (36” to 54” for the longer HydraSleeve) at a rate of about 1’ per second (or faster).

   The motion will open the top check valve and allow the HydraSleeve to fill (it should fill in about 1 to 1.5 times the length of the HydraSleeve). This is analogous to coring the water column in the well from the bottom up.

   When the HydraSleeve is full, the top check valve will close. You should begin to feel the weight of the HydraSleeve on the tether and it will begin to displace water. The closed check valve prevents loss of sample and entry of water from zones above the well screen as the HydraSleeve is recovered.

5. Continue pulling the tether upward until the HydraSleeve is at the top of the well.

6. Decant and discard the small volume of water trapped in the Hydrasleeve above the check valve by turning the sleeve over.

V. Sample Collection

Note: Sample collection should be done immediately after the HydraSleeve has been brought to the surface to preserve sample integrity.

1. Remove the discharge tube from its sleeve.

2. Hold the HydraSleeve at the check valve.

3. Puncture the HydraSleeve just below the check valve with the pointed end of the discharge tube

4. Discharge water from the HydraSleeve into your sample containers.

Control the discharge from the HydraSleeve by either raising the bottom of the sleeve, by squeezing it like a tube of toothpaste, or both.

5. Continue filling sample containers until all are full.

Measurement of Field Indicator Parameters

Field indicator parameter measurement is generally done during well purging and sampling to confirm when parameters are stable and sampling can begin. Because no-purge sampling does not require purging, field indicator parameter measurement is not necessary for the purpose of confirming when purging is complete.

If field indicator parameter measurement is required to meet a specific non-purging regulatory requirement, it can be done by taking measurements from water within a HydraSleeve that is not used for collecting a sample to submit for laboratory analysis (i.e., a second HydraSleeve installed in conjunction with the primary sample collection HydraSleeve [see Multiple Sampler Deployment below]).

Alternate Deployment Strategies

Deployment in Wells with Limited Water Columns

For wells in which only a limited water column exists to be sampled, the HydraSleeve can be deployed with an optional top weight instead of a bottom weight, which collapses the HydraSleeve to a very short (approximately 6" to 9") length, and allows the HydraSleeve to fill in a water column only 36" to 45" in height.

Multiple Sampler Deployment

Multiple sampler deployment in a single well screen can accomplish two purposes:

- It can collect additional sample volume to satisfy site or laboratory-specific sample volume requirements.
- It can accommodate the need for collecting field indicator parameter measurements.
- It can be used to collect samples from multiple intervals in the screen to allow identification of possible contaminant stratification.

It is possible to use up to 3 standard 30” HydraSleeves deployed in series along a single tether to collect samples from a 10’ long well screen without collecting water from the interval above the screen.

The samplers must be attached to the tether at both the top and bottom of the sleeve. Attach the tether at the top with a stainless-steel clip (available from the manufacturer). Attach the tether at the bottom using a cable tie. The samplers must be attached as follows (figure 4):

- The first (attached to the tether as described above, with the weight at the bottom) at the bottom of the screen
- The second attached immediately above the first
- The third (attached the same as the second) immediately above the second

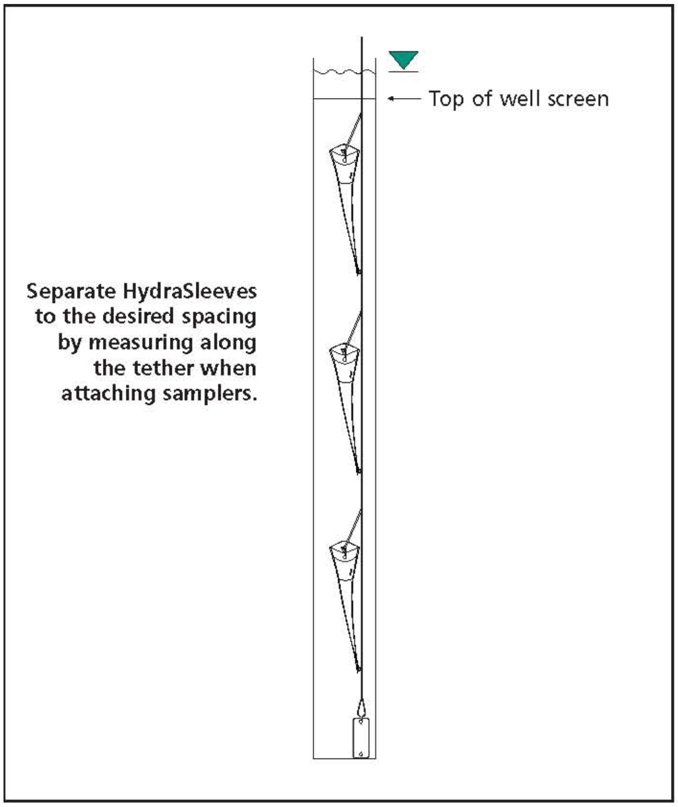


Figure 4. Multiple HydraSleeve deployment.

Alternately, the first sampler can be attached to the tether as described above, a second attached to the bottom of the first using a short length of tether (in place of the weight), and the third attached to the bottom of the second in the same manner, with the weight attached to the bottom of the third sampler (figure 5).

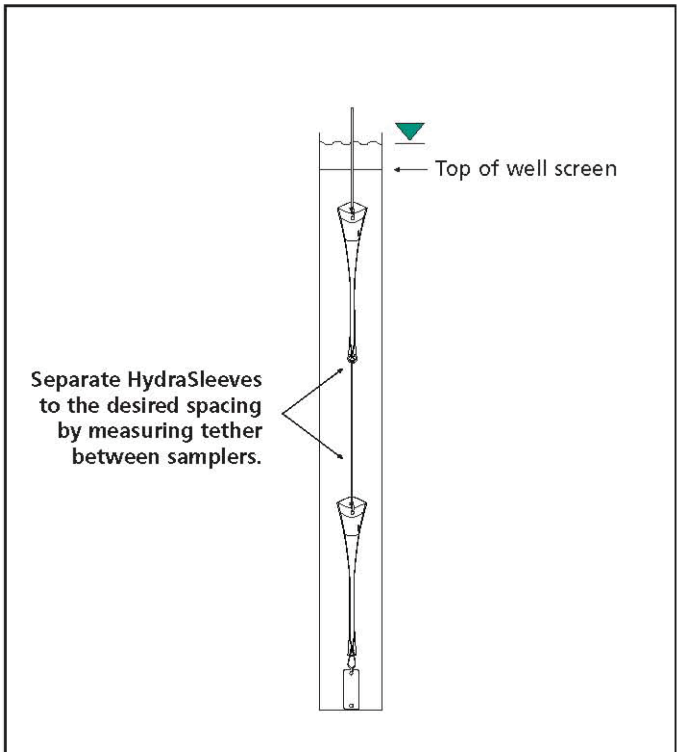


Figure 5. Alternative method for deploying multiple HydraSleeves.

In either case, when attaching multiple HydraSleeves in series, more weight may be required to hold the samplers in place in the well than would be required with a single sampler. Recovery of multiple samplers and collection of samples is done in the same manner as for single sampler deployments.

Post-Sampling Activities

The recovered HydraSleeve and the sample discharge tubing should be disposed as per the solid waste management plan for the site. To prepare for the next sampling event, a new HydraSleeve can be deployed in the well (as described previously) and left in the well until the next sampling event, at which time it can be recovered.

The weight and weight clip can be reused on this sampler after they have been thoroughly cleaned as per the site equipment decontamination plan. The tether may be dedicated to the well and reused or discarded at the discretion of sampling personnel.

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Appendix I – Administrative Requirements - Zoning

CERTIFIED STATEMENT FOR COUNTY AND MUNICIPAL ZONING REQUIREMENTS

The participant hereby certifies that the property meets all applicable county and municipal zoning requirements.

The participant acknowledges that there are significant penalties for falsifying any information required by MDE under Title 7, Subtitle 5 of the Environment Article, Annotated Code of Maryland, and that this certification is required to be included in a response action plan for the Voluntary Cleanup Program pursuant to Title 7, Subtitle 5 of the Environment Article, Annotated Code of Maryland.

Printed Name: Stephen Clarke

Title: President

Signature:

Date: 6/4/15

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