AECOM Environment

Prepared for:
City of Richmond

Prepared by:
AECOM
Bloomington, Indiana
September 2012

Remedial Action Work Plan
Ground Water Remediation and Site Capping Activities

Richmond Gas Plant
16 East Main Street
Richmond, Indiana
Brownfields Number 4980004

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1.0 Introduction

AECOM Technical Services (AECOM) has prepared this Remedial Action Work Plan (RAWP) on behalf of the City of Richmond to summarize the ground water remediation and soil capping activities planned for the former manufactured gas plant (MGP) site located in Richmond, Indiana (the Site). The City of Richmond is planning to redevelop the Site and include it as part of a recreational pedestrian walk and bike trail for the citizens of Richmond. A contaminant source removal action is currently underway and is scheduled for completion in 2012. The details of the source removal action are included in the Indiana Department of Environmental Management (IDEM)-approved Removal Action Work Plan prepared by AECOM dated November 2011 (AECOM, 2011). The Site is currently enrolled in the Indiana Brownfields Program and is assigned Number 4980004.

This RAWP has been developed to address chemicals of concern (COC) identified to the west of the former MGP property in ground water and to prevent human contact with COC-impacted surface and subsurface soil at the Site. Investigation and characterization of the nature and extent of MGP-related residuals and evaluation of potential exposure to COC has been conducted in accordance with the IDEM Risk Integrated System of Closure (RISC) Technical Guide and User Guide (IDEM, 2001) and has been submitted to the Indiana Finance Authority (IFA) for review and approval.

This RAWP is organized into twelve sections and five appendices. Section 1 provides introductory information and Section 2 provides background information. Section 3 provides a summary of the investigation activities. Section 4 discusses the source of contamination. Section 5 discusses the analysis of remedial alternatives and Section 6 discusses the remedial action plan. Section 7 provides the quarterly ground water monitoring and sampling plan. Section 8 discusses operation and maintenance. Section 9 discusses reporting and Section 10 includes the proposed remedial action plan schedule. Section 11 provides an estimate of the cost and Section 12 provides a list of references used in preparation of this report. Appendices include the following:

Appendix A Boring Logs and Well Completion Diagrams

Appendix B Laboratory Analytical Reports and Chain-of-Custody Forms

Appendix C Hydraulic Conductivity Test Results

Appendix D Analysis of Brownfield Cleanup Alternatives

Appendix E Site-Specific Health and Safety Plan

Appendix F Quality Assurance Project Plan

1.1 Project Background

The following sections provide background information for the Site.

1.1.1 Site Description

The former MGP facility originally covered an area of 2.26 acres and has been divided into three separate parcels since cessation of MGP operations. The eastern and central parcels, covering

0.44 and 0.38 acres respectively, are owned by Indiana Gas Company (IGC) and are located east of the C & O Railroad. The western parcel (the Site), covering 1.429 acres, is owned by the City of Richmond. The Site is located on the on the north side of East Main Street approximately 250 feet west of the intersection of East Main Street and North 2nd Street in Richmond, Wayne County, Indiana. The location of the Site is shown in **Figure 1**.

The Site is bounded to the north by Johnson Street; to the east by railroad tracks, beyond which are the two parcels owned by IGC; to the south by East Main Street, beyond which is additional commercial property; and to the west by a vacant lot covered with grass and tree vegetation owned by the City of Richmond.

All buildings on the Site were demolished in 2009. The Site currently is vacant and is covered by a mixture of gravel, former MGP facility rubble, and vegetation. The current Site layout is shown in **Figure 2**. Land use on adjacent properties is characterized as nonresidential. The nearest surface water body is the East Fork of the Whitewater River, located approximately 300 feet west of the Site. General surface topography of the Site slopes steeply to the north and west into Johnson Street and the Whitewater River floodplain. The slope then gently grades towards the riverbank and then steeply into the River.

1.1.2 Site Name and Address

Current Site Name:	Richmond Gas Plant 16 East Main Street Richmond, IN 47374
Property Owner:	City of Richmond Department of Metropolitan Development 50 North 5th Street Richmond, IN 47374
Site Representative:	Tony Foster Executive Director Department of Metropolitan Development 50 North 5th Street Richmond, IN 47374

1.1.3 Historical Summary

The Richmond MGP began production of gas using the coal carbonization process in approximately 1855. During 1882 and 1883, the plant was rebuilt and equipped with new machinery, and converted to the carbureted water gas process sometime thereafter. Between 1896 and 1901 the CR&M Railroad was granted a right-of-way, and the track separated the western and eastern portions of the former MGP. By 1909, the 320,000 cubic feet capacity gas holder was added to the eastern portion of the former MGP (the eastern parcels of the former MGP is not the subject of this RAWP). Gas manufacturing was put on standby for a period, and natural gas was distributed through its mains until November 1924, at which time the company again began to manufacture gas. The plant operated intermittently until approximately 1941. The remaining two gas holders, located in the southwestern portion of the former MGP (located on the Site), had capacities of 65,000 and 10,000 cubic feet. Other former MGP structures located on the Site included: a tar well, coal shed, retorts, generator room and meter room.

1.1.4 Past and Current Operations

The locations of former MGP structures, including two gas holders (65,000 cubic feet and 10,000 cubic feet), a tar well, coal sheds, retorts, a generator room and a meter room are depicted on **Figure 3**. Two brick tunnels containing MGP residual material are located beneath the former MGP building easement.

All remaining above-ground structures on the Site were demolished in 2009. The Site is currently vacant and ground cover is a mixture of gravel, former MGP facility rubble, and vegetation. The City of Richmond is planning to redevelop and incorporate a portion of the Site into the existing recreational pedestrian and bicycle trail. The remaining portion of the Site will likely be used as a parking area and/or roadway connecting East Main Street to the Veterans Memorial Park located north of Johnson Street.

1.1.5 Previous Investigations Conducted at the Site

Site investigations have been performed to delineate soil and ground water impacts associated with the former Richmond MGP site through means of records searches, subsurface structure identification, local hydrogeological investigations, surface and subsurface sampling, installation of ground water monitoring wells, and laboratory analysis of soil and ground water samples. Information and findings from previous Site investigative efforts is provided in the documents summarized in Section 1.2.1 below. It is the intent of this document to focus on the information pertinent to the ground water impacts to the west of the Site and the impacted surface and subsurface soil at the Site that remains following the source removal activities.

Multiple investigations were performed at the former Richmond MGP facility between 1994 and 2012 to determine the potential for environmental impacts related to past MGP operations, to identify the presence of MGP residuals, and to identify or confirm the presence of former MGP structures.

Subsurface structures at the Site identified during the previous investigation activities include a gas holder, a tar well, and multiple building foundations associated with historic gas plant activities. The former MPG building basement is located in the southern portion of the Site and contains a shallow well, approximately 8 feet below grade. An abandoned tunnel or cistern associated with the former MGP building was also identified during investigation activities. The removal of residual MGP material from the well in the basement, the removal of impacted water and MGP residual material from the abandoned tunnel/cistern, and the backfilling of the basement area and tunnel/cistern are included in the Removal Action Work Plan activities, which are currently scheduled for completion in 2012.

The COC identified in the ground water and soil during previous investigations include: benzene, ethylbenzene, total xylenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and total and weak acid dissociable (WAD) cyanide. The source areas for these COC have been identified as the former tar well in the northwest corner of the Site, the soil in the immediate vicinity of the former MGP building foundation, and the soil in the vicinity of one soil boring (SB-14) located near the northeast corner of the Site. A potential fourth source area has been identified (the former 65,000 cubic feet gas holder in the southern portion of the Site) and will be addressed as necessary during the source removal activities. The removal of source material from these targeted areas is addressed in the approved Removal Action Work Plan (AECOM, 2011).

A ground water investigation was conducted in July and August 2012 to delineate the extent of COC concentrations greater than their applicable RISC Default Closure Levels in the ground water to the west of the Site. The results of these investigation activities are included in this RAWP and have been utilized to develop the ground water remedial program detailed in Section 6.4 of this RAWP.

A summary of environmental investigations conducted at the Site include the following:

- Preliminary Assessment. A Preliminary Assessment (PA) was completed by RETEC in August 1993 and concluded that below-grade structures may contain MGP residuals.

- Site Inspection. A Site Inspection Report was completed by RETEC in October of 1995 addressing the evaluation of the vertical and horizontal extent of MGP residuals in subsurface soils. During the investigation, 22 soil borings were completed, four of which were converted to monitoring wells (MW-1 through MW-4). A concrete structure was encountered during the advancement of soil boring SB-A, and several attempts were made within an area of approximately 20 square feet to install the boring. The auger continually encountered refusal at a depth of approximately seven feet below ground surface (bgs). Soil boring observations indicated that the uppermost water bearing unit is located at approximately 13 to 21 feet bgs. Soil borings generally indicate that a four to ten foot layer of fill material extends across the Site, which is underlain by four to ten feet of silty sand and clay, which is underlain by bedrock.

  Generally, two soil samples were collected from each soil boring and analyzed for benzene, toluene, ethylbenzene, total xylenes (BTEX), polynuclear aromatic hydrocarbons (PAHs), and total cyanide. One soil sample was collected from soil borings SB-5 and SB-13, and three soil samples were collected from SB-20. Benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene concentrations were detected in soil samples SB-13, SB-14, and SB-20 above their respective Tier II Nonresidential Cleanup Goals. Benzene and naphthalene concentrations were detected in the ground water samples above the Tier II Nonresidential Cleanup Goals.

- Hydraulic Conductivity Testing. A Slug Testing Site Inspection was conducted by RETEC in February 1995 to address hydrogeologic data from the upper-most water-bearing unit at the Site. A detailed discussion of the hydrogeology is provided in a subsequent section of this report.

- Additional Site Investigation. An Additional Site Investigation was completed by RETEC in October 1995 to evaluate the lateral extent of soil and ground water impacts toward the Whitewater River. During the investigation, two soil borings/monitoring wells were installed (MW-101 and MW-102). Constituents detected included PAHs in soil and ethylbenzene, total xylenes, PAHs, and total cyanide in ground water. Concentrations of all constituents were less than the Tier II Nonresidential Cleanup Goals.

- Surface Soil Sampling. In 1996, RETEC completed a surface soil investigation to assess the impacts of MGP residuals in surface soil at the Site. Samples were collected at twelve locations across the Site (SS-1 through SS-12).

- Ground Water Monitoring. In 1996, RETEC collected ground water samples from monitoring well MW-102. The remaining wells were not sampled due to the observed presence of heavy sheen or light non-aqueous phase liquid (LNAPL) during the collection of static water levels.

- Purifier Parcel Remediation. In 2005, RETEC completed a soil remediation on a parcel of the former MGP property identified as the Purifier Parcel, located adjacent to the eastern boundary of the Site. During the remediation, three test pits were completed in the northwest portion of the Site in the area of the former tar well. The first two test pits (TP-01 and TP-02) were completed to a depth of approximately 15 feet. Both test pits found no indications of a tar well and the soil contained no visual staining. The photoionization detector (PID) headspace readings of the screened soil were 0.0 ppm. The third test pit (TP-03) located approximately 20 feet west of TP-01 and TP-02, was completed to a depth of approximately nine feet. At nine feet, a large piece of concrete, approximately four feet by three feet with a thickness of approximately six inches, was exposed and lifted by the excavator. Beneath the exposed piece of concrete was a structure containing water and a tar-like material. The concrete piece appeared to be covering the structure; however, only a portion of the structure was exposed, and no estimate of size could be determined. The concrete piece was put back in place and the soil placed back in the test pit. Visual staining of the soil was observed beginning at a depth of approximately seven feet.

- Supplement Subsurface Investigation. In 2007, Burgess and Niple conducted a subsurface investigation to investigate and define the former 65,000 and 10,000 cubic-foot (cf) gas holders, delineate subsurface tar by-product left from historical manufactured gas plant operations, and evaluate potential ground water impacts on the Site due to historical MGP operations. The investigation included the completion of two test pits, the installation of two monitoring wells (MW-05 and MW-06), and the completion of seven soil borings. Soil samples were collected from test pits completed in each holder. No other samples were collected.

- Phase II Investigation. A Phase II Site Investigation (Phase II) was conducted by Keramida, Inc. in May 2011. The investigation activities included soil borings, monitoring well installation, monitoring well gauging, and soil and ground water sample collection. Surface soil and subsurface soil samples were collected for analysis of BTEX, PAHs, total cyanide, WAD cyanide, and select metals. Ground water samples were collected for analysis of BTEX, PAHs, WAD cyanide, and select metals.

- Remedial Efforts to Define A Plume - 2012. In July and August 2012, AECOM completed six soil borings, installed seven monitoring wells, collected three subsurface soil samples, and collected eight ground water samples. Soil samples were collected for analysis of BTEX, PAHs, and total organic carbon (TOC). Ground water samples were collected for analysis of BTEX, PAHs, Resource Conservation and Recovery Act (RCRA) metals, total and ferrous iron, and total cyanide. A second mobilization was completed in September 2012 in preparation for the activities to be conducted under the approved Removal Action Work Plan. Two test pits were completed to identify the source areas targeted for removal activities and a third test pit was completed adjacent to MW-001, which has historically contained measureable amounts of LNAPL. The on-site test pitting identified one additional source area located adjacent to the existing former MGP building foundation. The third test pit identified the presence of free product in a perched aquifer located at the fill-clay interface; however, significant accumulation of free product did not occur and free product was not observed on the groundwater table below this interface.

1.2 Supporting Documentation

1.2.1 Previous Reports

The following documents have been prepared to summarize investigation activities completed at the Site:

- Preliminary Assessment, Former Manufactured Gas Plant Site, Richmond, Indiana. August 15, 1994 [PA] (RETEC, 1994).
- Site Inspection Report, Former Manufactured Gas Plant Site, Richmond, Indiana. March 31, 1995 [SI] (RETEC, 1995a).
- Slug Testing Report, Site Inspection, Former Manufactured Gas Plant Site, Richmond, Indiana. March 31, 1995 (RETEC, 1995b).
- Additional Site Investigation Report, Former Manufactured Gas Plant Site, Richmond, Indiana. January 12, 1996 (RETEC, 1996a).
- Surface Soil Sampling Report, Former Manufactured Gas Plant Site, Richmond, Indiana. May 31, 1996 (RETEC, 1996b).
- Ground Water Monitoring Summary, April 1996, Former Manufactured Gas Plant, Richmond, Indiana. June 21, 1996 (RETEC, 1996c).
- Soil Boring and Analytical Summary – December 2004, Former MGP Site – Richmond, Indiana, RETEC Project Number # IGC20-18598. Letter Report. February 16, 2005. (RETEC, 2005a).
- Supplemental Site Investigation Work Plan, Former Manufactured Gas Plant Site, Western Parcel (Main Process Area), Richmond, Indiana. May 26, 2005. (The RETEC Group, Inc., 2005b).
- State of Indiana Department of Natural Resources Division of water, Early Coordination/Environmental Assessment. DNR# ER-11607. Letter Correspondence. July 13, 2005. (IDNR, 2005).
- Remediation Completion Report, Purifier Parcel – Richmond MGP, Richmond, Indiana. August 18, 2005. (RETEC, 2005c).
- Supplement Subsurface Investigation, Former Manufactured Gas Plant, Richmond, Indiana. Letter Report. April 20, 2007. (Burgess and Niple, 2007).
- Phase II Investigation Report, Former Manufactured Gas Plant, 77 Johnson Street, Richmond, Indiana. June 11, 2011. (Keramida Inc., 2011).
- Removal Action Work Plan, Richmond Gas Plant, 16 East Main Street, Richmond, Indiana, Brownfields No. 4980004. November 2011. (AECOM, 2011).

A figure depicting the locations of all soil boring and monitoring well locations associated with the historical investigations is included as **Figure 4**. A table summarizing laboratory analytical results from activities conducted during the historical investigations is included in **Table 1**.

1.3 Remedial Action Objectives

The Site is currently a vacant lot with a cover of predominately graded fill material and dense vegetation. Current Site use is designated industrial with anticipated future use designated as recreational. The remedial objective for the Site under this RAWP is to ensure that exposure to affected media is sufficiently controlled to protect future receptors: construction workers and recreational patrons.

Remedial action needed to protect potential receptors within the Site by reducing the source area contaminant levels to below IDEM RISC levels should include the following:

- Treat MGP-impacted off-site ground water that could facilitate the migration of MGP impacts into off-site media, particularly the East Fork of the White River; and
- Eliminate or control potential exposure pathways for site workers and recreational patrons. This will include the implementation of an on-site cap.

The remedial action proposed in this RAWP addresses impacted ground water treatment and cap installation.

2.0 Background Information

The following information has been utilized to provide a framework for the site characteristics and assist with selection of an appropriate Site specific remedial program. Additional information regarding the exposure evaluation for COC at this Site may be found in Section 2.4 of the approved Removal Action Work Plan for source removal prepared by AECOM, dated November 2011.

2.1 Summary of Information Used to Select Remedy

2.1.1 Regional Geology

According to RETEC (RETEC 2005b), the Richmond area is underlain by Ordovician-aged skeletal limestone and calcareous shale from the Whitewater Formation included in the Maquoketa Group. Regionally, the Maquoketa Group is a westward-thinning wedge of rocks, approximately 700 to 1,000 feet thick in the basin, and consists primarily of shale in the lower part and limestone with smaller amounts of shale in its upper part. The major geologic structure in the Whitewater River basin is the Cincinnati Arch. Well records obtained from the Indiana Department of Natural Resources (IDNR) Water Division indicate that shale is likely to be the first bedrock material encountered at 19 feet below ground surface (bgs) at the Site. Wayne County lies in the Tipton Till Plain Physiographic section of Indiana.

Surficial materials in the Richmond area are underlain by mixed drift consisting of till and stratified drift in lineated form. The tills are primarily of the Trafalgar Formation and are a result of glacial advances. The lineated forms indicate collapse associated with sub-ice tunnels and ice-walled channels. The till consists of loam to sandy loam that contains abundant pebbles and cobbles, and scattered beds and lenses of silt, sand and gravel. The surface of the till has been only slightly modified by erosion since the till was deposited. A layer of weathered till (yellow/gray clay) ranging in thickness from three feet to 37 feet is indicated for the majority of the borings for which logs were available (IDNR). The USDA soil survey of Wayne County indicates that the Site soil is from the Eden association, which is steep to very steep, moderately deep, well-drained soil on upland side slopes.

2.1.2 Regional Hydrogeology

According to RETEC (RETEC 2005b), till deposited in the area of the Site contains beds and lenses of coarse-grained materials which are important locally because they serve as aquifers primarily for domestic and agricultural purposes. In some areas along the Whitewater River, thick and permeable deposits of sand and gravel exist, which constitute the major source of ground water in the region. Other regions in the Richmond area, including the area of the Site, contain only scattered deposits of sand and gravel. Water availability in the area of the Site is limited to these scattered sand and gravel deposits. Various logs from wells indicated that the sand and gravel aquifer, encountered at depths ranging from 28 to 70 feet, is utilized in the Richmond area. Wells located along the Whitewater River have been developed and yield over 1,000 gallons per minute (gpm) in the underlying sand and gravel. Wells located outside an approximate one-half mile radius from the river have a potential yield of only ten gpm from properly constructed wells.

The bedrock aquifer which occurs in the area of the Site is the Ordovician Bedrock Aquifer. Ordovician age bedrocks form a thick sequence of shales, limestones, dolomite, and sandstones. Ground water potential in the Maquoketa Group rocks is poor because they are essentially impermeable. Shale is the most commonly occurring bedrock material near the Site. In some areas the shale is covered by sandstone. Records from IDNR indicate that the limestone unit can be used as a source of ground water in the Richmond area.

2.1.3 Physical and Political Geographic Information

The Site slopes to the northwest, with elevations ranging from 942 to 905 feet above mean sea level (MSL). Some of the Site topography can be attributed to filling/grading associated with former facility operations and deposition of construction debris generated during a downtown Richmond gas explosion in 1968. The largest surface water body near the Site is the East Fork Of the Whitewater River, located approximately 475 feet west of the former MGP property.

The Site is located in a commercial/industrial area within the City of Richmond. The geographic location of the Site is 84◦53’57.93” west longitude and 39◦49’47.75” north latitude.

2.1.4 Identification of Susceptible Areas

The IDEM RISC Policy identifies three types of areas that are thought to be especially vulnerable to potential harm from contamination: geologically susceptible areas, wellhead protection areas, and ecologically susceptible areas. The following discussion provides a review of the Site setting with respect to these areas.

- **Geologically Susceptible Area Evaluation:** The presence of Karst terrain has not been observed in boring logs or reported in the vicinity of the Site.

- **Wellhead Protection Areas:** IDEM identified the Site as being located within a Wellhead Protection Area. According to RETEC, the City of Richmond well field lies approximately 0.6 mile south of the former MGP. It consists of a cluster of three wells that are all screened in the outwash deposits at an approximate depth of 59, 60 and 62 feet below ground surface.

- **Baseline Ecological Evaluation:** As stated previously, the majority of the Site is covered by fill or vegetation. The Site is not located within a designated forest, wildlife refuge, or other protected area. No surface water is present, and no rare or endangered species have been observed at the site. A letter from the Indiana Department of Natural Resources (IDNR) regarding the adjacent property states, “To date, no plant or animal species listed as a state of federally threatened, endangered, or rare have been reported to occur in the project vicinity” (IDNR, 2005).

3.0 Remedial Efforts To Define A Plume

3.1 Ground Water Assessment

The results of the historical investigations at the Site indicated that additional dissolve-phase COC delineation to the west of the Site and characterization of the LNAPL encountered at MW-001 was required in order to complete the development of the remedial action program.

To further delineate the COC in the ground water located to the west of the Site, six monitoring wells were installed, developed, and sampled between July 31 and August 17, 2012. Six soil borings were also completed during this investigation to evaluate subsurface soil conditions. LNAPL transmissivity tests were performed at MW-001 to determine the recovery rate of LNAPL into the well. Hydraulic conductivity tests were conducted to determine Site-specific ground water flow conditions in the weathered bedrock/gravel aquifer identified during this investigation.

3.1.1 Materials and Methods

3.1.1.1 Soil Boring Activities

The activities completed under the Ground Water Investigation commenced on July 31, 2012. Soil borings SB-12-01 through SB-12-05 and SB-MW-009 and monitoring wells MW-010 through MW-014 were completed using a track-mounted Geoprobe® 6620DT direct push rig outfitted with Hollow Stem Auger (HSA) equipment. Monitoring wells MW-012D and MW-015 were completed using a truck-mounted HSA rig.

A total of six soil borings (SB-12-01, SB-12-02, SB-12-03, SB-12-04, SB-12-05, and SB-MW-009) were completed using direct push methods, which allowed for continual collection and logging of soil cores. The locations of the soils borings are provided in **Figure 5** and soil boring logs are provided in **Appendix A**.

Soil boring SB-12-01 was completed to characterize soil conditions at the presumed limit of the ground water plume in the vicinity of monitoring wells MW-101 and MW-102. SB-12-02 was completed to characterize real-time subsurface soil conditions at the Site. Soil borings SB-12-03, SB-12-04, and SB-12-05 were advanced adjacent to the sanitary sewer line along the western property boundary to investigate the sewer line backfill as potential preferential pathway. An IDEM representative was on-site to observe the advancement of these three soil borings. The soil borings were advanced to depths ranging from 16 feet to 20 feet below ground surface (bgs), as directed by the IDEM representative. SB-MW-009 was intended to be completed as a monitoring well; however, competent bedrock was encountered prior to the ground water table and a monitoring well was not installed at this location.

Undisturbed soil samples were collected from SB-12-02 and MW-015 for laboratory analysis of porosity, grain size, and permeability to evaluate if soil conditions are conducive to ground water remediation by chemical injection. The two undisturbed soil samples were delivered via overnight courier to TestAmerica Laboratories, Inc. located in South Burlington, Vermont.

Subsurface soil samples were collected from SB-12-02 and MW-015 to evaluate current on-site and off-site conditions. One subsurface soil sample was collected from SB-12-02 and one subsurface soil sample and one saturated soil sample were collected from MW-015 and submitted for laboratory analysis of BTEX, PAHs, and total organic carbon (TOC). The soil samples were collected using laboratory-supplied sample media and place on ice in a laboratory-provided sample cooler and delivered to Pace Analytical Services, Inc. in Indianapolis, Indiana. The laboratory analytical results of the subsurface soil and saturated soil samples are summarized in **Table 2** and the laboratory analytical reports and chain-of-custody forms are provided in **Appendix B**.

3.1.1.2 Monitoring Well Installation and Development

A total of seven monitoring wells (MW-010, MW-011, MW-012S, MW-012D, MW-013, MW-014, and MW-015) were installed as part of this investigation. All monitoring wells were completed using Schedule 40 PVC riser pipe and 0.010-inch slot PVC well screens. The wells screens at MW-010, MW-011, MW-012S, and MW-013 were completed as ten feet in length. The well screen at monitoring well MW-013 was completed at five feet in length. The well screens at monitoring wells MW-012D and MW-015 were completed at 20 feet and 15 feet in length, respectively. Longer screen lengths were used to ensure that zones of representative water from the aquifer, as well as any potential LNAPL, would be captured. A filter pack comprised of clean quartz sand of uniform grain size was placed around the well screens to a depth of no less than one foot above the screen.

Each monitoring well was developed following installation using an electric submersible pump with new low-density polyethylene tubing. The flow rate of the pump was set at a sufficient speed to remove fine-grained sediment from the well while minimizing drawdown of the water level within the well. Development continued until either turbidity stabilized at the lowest value attainable value or a maximum of ten well volumes had been removed. All development water generated was stored in Department of Transportation (DOT)-approved 55-gallon open-top steel drums staged at the Site pending off-site transportation and disposal.

Monitoring well construction logs are provided in **Appendix A**. Monitoring well and soil boring locations are provided in **Figure 5**.

3.1.1.3 Ground Water Sample Collection

Ground water samples were collected from eight of eleven new installed and existing monitoring wells (MW-006, MW-008, MW-010, MW-011, MW-12D, MW-15, MW-101, and MW-102) using low-flow sampling methods. Monitoring well MW-001 was not sampled due to the measurable presence of LNAPL. Monitoring wells MW-012S, MW-013, and MW-014 were not sampled due to the absence of ground water, which could be attributed to recent drought conditions. Monitoring well MW-12D was installed at a deeper depth, adjacent to monitoring well MW-12S as groundwater analytical information at this location was deemed critical to complete Site evaluation. The water quality meter was bypassed during purging at MW-006 to protect this instrumentation as a result of NAPL globules observed in the water column.

Water level, total depth, and LNAPL thickness were collected using an oil-water interface meter with an accuracy of 0.01 foot. The measurements were used to evaluate the direction of ground water flow and determine the presence or absence of NAPL in the monitoring wells. A list of monitoring wells, ground water measurements, and their associated elevations are summarized in **Table 3**. A figure summarizing the ground water flow within the confined weathered bedrock/gravel layer is provided as **Figure 6**.

In order to facilitate groundwater sampling, each monitoring well was purged using a QED SamplePro Portable bladder pump. All ground water samples were collected using new low-density polyethylene tubing and bladders. During the purging process, ground water elevations and water quality parameters including pH, conductivity, oxidation-reduction potential, temperature, dissolved oxygen, and turbidity were measured and recorded at three to five minute intervals. Prior to sampling, each monitoring well was purged until stabilization of field parameters was achieved. All purge water generated was stored in DOT-approved 55-gallon open-top steel drums staged at the

Site pending off-site transportation and disposal. Water quality parameters at the time of sample collection are provided in **Table 4**.

Ground water samples were collected using laboratory-provided sample media and placed on ice in laboratory-provided sample coolers immediately following collection. Samples were delivered to Pace Analytical Services, Inc. in Indianapolis, Indiana and analyzed for BTEX, PAHs, RCRA metals, total and ferrous iron, and total cyanide. Ferrous iron measurements were collected in the field, with the exception of MW-006, which was submitted for laboratory analysis of ferrous iron. A summary of sample analyses are provided in **Table 5**. A table summarizing the ground water analytical results is provided in **Table 6** and the laboratory analytical report and chain-of-custody forms are provided in **Appendix B**. A figure depicting ground water concentrations of COC greater than their applicable RISC Default Closure Levels is provided as **Figure 7**.

3.1.1.4 Hydraulic Conductivity Test

Hydraulic conductivity tests were completed at MW-010. A pressure transducer was lowered to the base of the well screen and was used to continually measure water pressure and the corresponding water level in the well. A solid cylinder plastic slug was used to displace the water within the well during each of the tests. A falling head test was conducted by inserting the slug in the water column and measuring the water level as it falls to a static level. A rising head test was conducted by removing the slug from the water column and measuring the water level as it rises to a static level. The results of the falling head and rising head hydraulic conductivity tests are provided in **Appendix C**.

3.1.1.5 Transmissivity Testing and LNAPL Characterization

LNAPL transmissivity tests were conducted at MW-001 during this investigation. Initial LNAPL thicknesses were measured using an oil-water interface meter. Following measurement, LNAPL was removed from the well using a peristaltic pump until all LNAPL was removed from the water column and filter pack and the recovering LNAPL thickness was measured and recorded at specified intervals to determine the recovery rate.

Following removal, a sample of the purged LNAPL was collected and submitted to Torkelson Geochemistry, Inc. in Tulsa, OK for density, viscosity, and fingerprinting analysis in an effort to characterize and verify the LNAPL source.

3.2 Results

3.2.1 Field Observations

Visual and olfactory observations and PID headspace readings of the cores retrieved from the soil borings and monitoring wells indicated the presence of residual MGP material at the base of the fill and within the clay/silt layer to the west of the Site. Visual and olfactory observations and PID headspace readings of saturated soil impacts were evident in the monitoring wells completed adjacent to the northwest corner of the Site (MW-012S, MW-012D, and MW-015). One subsurface soil and one saturated soil sample was collected from MW-015 to delineate the extent of their respective impacts, the results of which were used in the calculations for remedial options.

The monitoring wells and soil borings completed to the north and northwest of the Site (SB-MW-009, MW-010, and MW-013) did not display evidence of subsurface soil or saturated soil impacts. In addition, the laboratory analytical results of the ground water samples collected during this investigation indicate that dissolved-phase impacts in the weathered bedrock/gravel confined aquifer are limited to the west of the Site. During the August 2012 ground water sampling, it was discovered that three of the monitoring wells (MW-012S, MW-013, and MW-014) did not contain water, which could be attributed to the recent drought conditions.

A summary of subsurface matrix conditions is presented below:

- **Surface soil:** The upper six inches of soil, light olive green to dark brown or black, moist organic rich loam. Non-fill surface soil was encountered only in the northern portion of the Site.

- **Surficial fill and debris:** Loam, with varying amounts of sand, gravel, and debris that includes brick, coal, cinders, and concrete. The fill unit ranges in thickness from one foot to eighteen feet and reaches its maximum thickness in the southeastern corner of the site (near the former building basement).

- **Clay:** Relatively thick, moist green-gray clay unit with up to 20% limestone fragments. The unit ranges in thickness from 4.5 feet to greater than 22.8 feet and overlies a bedrock and/or gravel layer at a depth between approximately 13 and 26.5 feet bgs.

- **Weathered bedrock & gravel:** Weathered limestone containing up to 50% gravel ranging from 13 to 26.5 feet bgs. This unit is saturated and believed to represent the true groundwater table beneath the site.

Geologic cross-sections of the Site and their respective locations are provided in **Figure 8** and **Figure 9**. The water table has been observed at depths ranging from approximately 13.5 to 21 feet bgs. Static ground water measurements from the August 2012 ground water sampling are summarized in **Table 3**. A potentiometric surface map of these data is provided as **Figure 6**.

The intent of the Remedial Efforts to Define a Plume was to delineate the extent of the dissolved-phase plume; however, during the course of activities, it was determined that additional data was required in the area immediately downgradient of MW-001. Monitoring wells MW-012D and MW-015 were installed and sampled subsequent to the initial ground water sampling activities to determine the concentration of COC downgradient from MW-001 and to determine if the LNAPL that is present in MW-001 is mobile beyond that point.

3.2.2 Laboratory Analytical Results

The laboratory analytical results for the subsurface soil and saturated soil samples collected during this investigation are summarized in tabular form in **Table 2**. The laboratory analytical results for the ground water samples collected during this investigation are summarized in tabular form in **Table 6**. The laboratory analytical reports and chain-of-custody forms are provided in **Appendix B**.

3.2.2.1 Subsurface Soil

A brief summary of the laboratory analytical results of the subsurface soil samples are provided below:

- Benzene was detected at a concentration greater than the RISC Residential Default Closure Level (RDCL) at MW-015.

- Benzene was detected at a concentration greater than the RISC Industrial Default Closure Level (IDCL) at SB-12-02. Additionally, ethylbenzene was detected at a concentration greater than the RISC RDCL but less than the IDCL.

- Benzo(a)pyrene was detected at a concentration greater than the RISC IDCL at MW-015. Naphthalene was also detected at a concentration greater than the RISC RDCL but less than the IDCL.

- Benzo(a)pyrene and dibenzo(a,h)anthracene were detected at concentrations greater than their respective RISC IDCL at SB-12-02. Four additional PAH constituents, including naphthalene, were detected at concentrations greater than their respective RISC RDCL but less than their respective IDCL.

3.2.2.2 Saturated Soil

A brief summary of the laboratory analytical results of the single saturated soil sample collected from boring MW-015 during this investigation is provided below:

- Benzene was detected at a concentration greater than the RISC IDCL.

- Benzo(a)pyrene and naphthalene were detected at concentrations greater than their respective RISC RDCL but less than their respective IDCL.

3.2.2.3 Ground Water

A brief summary of the laboratory analytical results of the ground water samples are provided below:

- Benzene was detected at a concentration greater than the RISC IDCL at MW-006 and MW-012D. Benzene was detected at a concentration greater than the RISC RDCL but less than the IDCL at MW-015. Ethylbenzene was also detected at a concentration greater than the RISC RDCL but less than the IDCL at MW-006.

- Benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h)anthracene were detected at concentrations greater than the RISC IDCL at monitoring wells MW-006, MW-012D, and MW-015. One or more PAH constituent, including naphthalene, were detected at concentrations greater than their respective RISC RDCL but less than their respective IDCL at monitoring wells MW-006, MW-011 (and the duplicate), MW-012D, and MW-015.

- Total cyanide was detected at a concentration greater than the RISC IDCL at MW-006. Total cyanide was detected at a concentration greater than the RISC RDCL but less than the IDCL at MW-015.

3.2.2.4 LNAPL Transmissivity Testing and Fingerprinting Results

The transmissivity test was conducted on August 16, 2012. The test was conducted for six hours and measurable product was not detected until two hours into the test. The results of this test demonstrated that the LNAPL is not of the typical “floating lens” model, based upon the very slow recharge time. It appears that the LNAPL is being forced down the hillside through the weathered bedrock/gravel aquifer by hydraulic pressure and is slowly gravitating towards the well screen and bubbling up to the top of the water column, a model similar in nature to that of an oil-water separator. The source of the LNAPL appears to be the previously-identified on-site MGP source areas. It is anticipated that the flow and accumulation of LNAPL in monitoring well MW-001 will cease as a result of the source removal activities completed under the approved Removal Action Work Plan (AECOM, 2011).

As noted above, a sample of the purged LNAPL was collected and submitted to Torkelson Geochemistry, Inc. in Tulsa, OK for density, viscosity, and fingerprinting analysis. The laboratory fingerprinting analysis indicated that the likely source of this material is weathered coal tar liquids. The density of the LNAPL was reported to be 0.9914 gram per milliliter (g/mL) and the viscosity was reported to be 28.5 centipoise. The complete Torkelson Geochemistry Report is included in **Appendix B**.

4.0 Sources of Contamination

The conceptual model for the Site (AECOM, 2011) indicates that contamination is present in affected media as a result of the following:

- Past releases of MGP residuals to subsurface media from former MGP process structures including tar wells, gas holders and associated piping; and,
- Use and placement of fill, presumably for Site grading purposes and from residual construction debris resulting from the downtown explosion in 1968.

The previous CSM has been updated with the following information in order to develop the Site remedial program included in this RAWP.

4.1 Extent of Contamination

Investigations completed to date include screening and collection and analysis of surface soil, subsurface soil, and ground to delineate the nature and extent of MGP impacts. Given that the Site will be developed as part of a recreational area by the City of Richmond, the results of soil and ground water samples collected from on-site locations have been compared to Closure Levels established in the RISC Policy as follows:

- Surface soil data have been compared to Recreational Nondefault Closure Levels (RNCLs) and Construction Worker Direct Contact Closure Levels (CWDCs);
- Subsurface soil data have been compared to Residential and Industrial Migration to Ground Water (R-MTGW and I-MTGW, respectively) and CWDC Closure Levels; and,
- Ground water data have been compared to the Ground Water Residential and Industrial Default Closure Levels (GW-RDCLs and GW-IDCLs, respectively)

As noted above, it is anticipated that the 2012 MGP source removal activities will significantly reduce the LNAPL accumulation in monitoring well MW-001, therefore, direct LNAPL remediation, other than periodic monitoring and removal (if necessary) is not included in this RAWP.

4.1.1 Surface Soil

As noted above, the appropriate RISC closure levels for on-site and off-site surface soil are RNCLs and CWDCs. A summary of the historical surface soil analytical data at the Site is summarized in **Table 7**. This information is also included in the approved 2011 Removal Action Work Plan.

Concentrations of COC reported in surface soil samples collected were all below CWDCs. Concentrations of BTEX and cyanide were below RNCLs. The results of the surface soil samples indicate that concentrations of one or more PAH compound(s) and one or more metal compound(s) were reported above RNCLs in 33 samples (and 3 duplicates). **Figure 10** shows the locations of samples with detected concentrations of one or more COC reported above RNCLs. A summary of the PAH and metal compounds detected during previous investigations and a range of reported concentrations is provided below.

- Benzo(a)anthracene: Concentrations ranged from below detection limits to 60 mg/kg in the sample collected from TS-SS-09.

- Benzo(a)pyrene: Concentrations ranged from below detection limits to 43 mg/kg in the sample collected from TS-SS-09.

- Benzo(b)fluoranthene: Concentrations ranged from below detection limits to 30 mg/kg in the sample collected from TS-SS-09.

- Dibenzo(a,h)anthracene: Concentrations ranged from below detection limits to 13 mg/kg in the sample collected from TS-SS-09.

- Indeno(1,2,3-cd)pyrene: Concentrations ranged from below detection limits to 25 mg/kg in the sample collected from TS-SS-15.

- Arsenic: Concentrations ranged from 2.9 mg/kg in the sample collected from TS-SS-9 (0.5-1') to 28 mg/kg in the sample collected from TS-SS-15 (0-0.5')

- Lead: Concentrations ranged from 8.2 mg/kg in the sample collected from TS-SS-10 to 600 mg/kg in the sample collected from TS-SS-15.

The results from the surface soil samples demonstrate that the Site is delineated to CWDCs for all COC. The Site is delineated to RNCLs for volatile organic constituents (VOCs) associated with MGP residuals and cyanide. PAH exceedances of RNCLs in surface soil were observed to be widespread throughout the Site. Arsenic exceedances of RNCLs in surface soil were observed in the northwest and southern sections of the site. Surface soil is evaluated further in Section 2.4 of the Removal Action Work Plan (AECOM, 2011).

4.1.2 Subsurface Soil

As noted above, the appropriate RISC closure levels for on-site soils are R-MTGW, I-MTGW and CWDC. A summary of subsurface soil analytical data is summarized in **Table 8**.

The results from the subsurface soil samples from on-site locations indicate that detected concentrations of BTEX, one or more PAH compounds, arsenic, lead and total cyanide were reported above closure levels in 23 samples (and 3 duplicates). **Figure 11** shows the locations of samples with detected concentrations of one or more COC reported above R-MTGW, I-MTGW and CWDC closure levels.

The results from the subsurface soil samples demonstrate that conditions are generally delineated to CWDCs. PAH exceedances of CWDC closure levels were observed in the northeast portion of the Site. Lead exceedances of CWDC closure levels were observed in the southeast portion of the site (near the old building basement). BTEX and multiple PAH exceedances of R-MTGW and I-MTGW closure levels were observed to be widespread throughout the Site in subsurface soil and have not been fully delineated. Similar to surface soils, subsurface soil is evaluated further in Section 2.4 of the Removal Action Work Plan (AECOM, 2011).

4.1.3 Ground Water

A summary of historic ground water analytical data is provided in **Table 9** including the results from this investigation. Ground water sampling locations containing COC in excess of RISC Closure Levels during past investigation activities are shown on **Figure 12**. Analytical results from the multiple ground water sampling events demonstrate that BTEX, several PAHs, arsenic and cyanide both on-site and downgradient off-site exceed GW-RDCLs and GW-IDCLs. The extent of off-site COC-impacted ground water is presented in **Figure 13**.

4.2 Risk Assessment

Investigation and characterization of the nature and extent of COC associated with former MGP operations at the Site has been conducted in accordance with the RISC Technical Resource Guidance Document (Technical Guide). It is apparent from this assessment that the risks associated with residual COC include recreational and worker exposure to impacted surface and subsurface soils at the Site as well as exposure of the East Fork of the White River to impacted ground water identified to the west of the Site. Section 5.0 includes an analysis of remedial alternatives to address these COC.

5.0 Analysis of Remedial Alternatives

This Analysis of Remedial Alternatives (ARA) presents five remedial alternatives considered to address affected ground water migrating to the west of the Site. An Analysis of Brownfields Cleanup Alternatives (ABCA) to address impacted Site soil was recently completed for IDEM and the United States Environmental Protection Agency (U.S. EPA) to support the source removal activities under the approved Removal Action Work Plan (AECOM, 2011). The ABCA includes institutional controls to protect recreational users of the Site in addition to source removal activities. A copy of the ABCA is included in **Appendix D**. The recommended remedial alternative will be implemented to address affected ground water and will complement the source removal activities summarized in the ABCA and the approved Removal Action Work Plan (AECOM, 2011).

5.1 Analysis of Alternatives

Cleanup alternatives considered to mitigate exposure to impacted ground water included the following:

- Alternative One – Monitored Natural Attenuation
- Alternative Two – Ground Water Pumping and Treatment
- Alternative Three – In-Situ Chemical Oxidation Injection
- Alternative Four – In-Situ Biodegradation Injection
- Alternative Five – Site Capping

The remedial action alternatives considered were evaluated using the following criteria:

(1) Effectiveness

a. The degree to which the toxicity, mobility and volume of the contamination is expected to be reduced (i.e., the ability to reduce or destroy contaminant mass).

b. The degree to which a remedial action option, if implemented, will protect public health, safety and welfare and the environment over time.

c. The degree to which implementation of remedial activities will adversely impact public health, safety and welfare and the environment.

(2) Implementability

a. The technical feasibility of constructing and implementing the remedial action option at the site or facility.

b. The availability of materials, equipment, technologies and services needed to conduct the remedial action option.

(3) Cost

a. Capital costs, including both direct and indirect costs;

b. Initial costs, including design and testing costs.

c. Annual operation and maintenance costs.

5.2 Ground Water Alternative Analysis

5.2.1 Alternative 1 – Monitored Natural Attenuation

Monitored natural attenuation is a passive remedial option which relies on natural processes including biodegradation and volatilization to reduce COC levels. Active quarterly monitoring is required for this alternative.

(1) Effectiveness – Provided that the COC source is removed, monitored natural attenuation should be effective in documenting decreasing ground water impacts over time. The drawbacks to this approach include a significant period (several years) to reduce or eliminate COC and the continued potential for COC to reach the East Fork of the Whitewater River before adequate attenuation.

(2) Implementability - Implementation would be simplistic as it will only require quarterly ground water sampling and analysis.

(3) Total Cost – ($10,000+) includes quarterly ground water monitoring cost ($10,000 per quarter) for an indeterminate number of quarters.

5.2.2 Alternative 2 – Ground Water Pumping and Treatment

Design and installation of a remedial system which pumps impacted ground water to a treatment system capable of removing COC by carbon treatment, aeration or biological means.

(1) Effectiveness – Ground water pumping and treatment will effectively contain the contaminant plume and protect the East Fork of the Whitewater River from impact, however, reduction in plume size may not result. In addition, measured LNAPL at the site does not warrant the installation of a costly free product recovery system. This treatment alternative will require construction of a permanent treatment system and ongoing operation and maintenance, resulting in the highest cost remedial alternative.

(2) Implementability – Significant initial design and construction effort and associated cost required to implement in the short term. Long term personnel and equipment requirements for operation, maintenance and monitoring. Discharge permitting for treated water may be required.

(3) Cost – Total Cost ($450,000+) includes system installation cost ($350,000) and operation and maintenance costs ($100,000 per year) for an indeterminate period. Capital and O&M costs included .

5.2.3 Alternative 3 – In-Situ Chemical Oxidation Injection (ISCO)

Injecting a strong oxidant into the ground water plume to reduce mass and destroy COC.

(1) Effectiveness – ISCO can effectively reduce residual COC concentrations by destruction upon contact. This alternative can be implemented over a generally short time span and has been effective on residual COC at other locations. This alternative will not be effective over the long term if a persistent source remains at the Site. Health and safety consideration as remedial process may result in an exothermic reaction at the time and point of injection.

(2) Implementability – Although COC destruction and reduction may be achieved with a single injection event, a series of three injection events are typical to achieve destruction and reduction goals. Ground water sampling and analysis should be conducted prior to the first event and following each of the three injection events to monitor remedial progress.

(3) Cost – Total Cost ($283,000) includes injection costs for three events ($243,000) and monitoring costs for four quarters ($40,000). All capital costs, no O&M costs.

5.2.4 Alternative 4 – In-Situ Biodegradation Injection

Injecting a substrate into the ground water plume to stimulate growth of desirable indigenous bacteria that consume COC.

(1) Effectiveness – This option would effectively reduce the COC concentrations by degrading COC over time and enhancing natural attenuation. This alternative will not be effective over the long term if a persistent source remains at the Site.

(2) Implementability – It is likely that at least 3 injection events would be required to reduce COC. An additional incubation time beyond injection events would be required to allow biodegradation of COC to acceptable levels. In-situ biodegradation treatment should address lighter COC such as benzene, but may take longer to address PAHs. Depending upon the acceptability of the biodegradation rate, additional injection beyond 3 events could be required.

(3) Cost – Total Cost ($256,000) includes injection costs for three events ($216,000) and monitoring costs for four quarters ($40,000). All capital costs, no O&M costs.

5.2.5 Alternative 5 – Site Capping

Covering the Site with low permeability soil (clay) to reduce infiltration of precipitation into the residual impacted soil (i.e., reduce potential for migration to ground water) and restricting contact with construction workers and recreational users.

(1) Effectiveness – This option would effectively reduce the potential for continued ground water impacts from Site soil and protect construction workers and recreational Site users from contact with impacted soil.

(2) Implementability – Cap design and placement is relatively simple and effective, although some additional effort is required to add topsoil and plant grass over the capped area. Additional engineering considerations will also be required to account for an asphalt road

planned by the City of Richmond to cross the cap. The asphalt surface may be incorporated into cap design as alternative impermeable cover.

(3) Cost – Site Capping ($262,000) includes cap placement ($190,000) and topsoil placement and seeding ($72000). All capital costs, no O&M costs.

5.2.6 Ground Water Recommendation

Alternative 1 (Monitored Natural Attenuation) requires the least amount of engineering and design and is the least expensive option in the short term. This alternative does not meet the objective to reduce or destroy contaminant mass. Further, this alternative does not provide a known timeline and does not promptly address potential migration of COC to the East Fork of the Whitewater River. Alternative 2 (Ground Water Pump and Treatment) is the most costly alternative and would require installation of a system within the flood plain and substantial O&M costs. Alternative 3 (In-situ Chemical Oxidation Injection) is an initially costly option that will reduce and destroy COC mass almost immediately. Residual COC above cleanup goals could be eliminated with additional injection events. Alternative 4 (In-Situ Biodegradation Injection) is a slightly less costly injection option, but adequate COC reduction and/or destruction will not take place immediately. It is likely that this option will require additional injection events and may not achieve PAH cleanup goals. Alternative 5 (Site Capping) eliminates the potential for direct contact with MGP-affected soils and reduces the potential for COC migration to ground water.

The recommended remedy for ground water complements the ABCA recommendation for soil and the source removal activities completed under the approved Removal Action Work Plan (AECOM, 2011). The recommended remedy is a combination of Alternative 3 (In-Situ Chemical Oxidation Injection), Alternative 4 (In-Situ Biodegradation Injection) and Alternative 5 (Site Capping). This combination will reduce and destroy COC mass immediately through chemical oxidation, allow for continued long-term reduction of COC through biodegradation, and reduce the potential migration of residual COC in soil to ground water by eliminating the infiltration of precipitation. Further, as noted above, Site capping will eliminate the potential direct contact to residual COC in surface soils for future site workers and recreational patrons.

6.0 Remedial Action Plan

6.1 Description of Removal Action

The selected remedial action program for this Site involves two activities, Site capping and in-situ ground water remediation, in addition to the source removal and institutional controls being implemented under the source removal program (AECOM, 2011). The purpose of the site capping will be to prevent contact of COC-impacted soil with construction workers and recreational users and to prevent infiltration and contact of precipitation with COC impacted soil. The purpose of the in-situ ground water remediation will be to reduce COC concentrations and destroy COC mass in impacted ground water to the west of the Site and protect the East Fork of the Whitewater River from COC impacts.

This remedial program is predicated on successful completion of the COC source removal program currently under way at the Site. Successful source removal is anticipated to eliminate the on-site source of LNAPL as well as significantly reduce the on-site mobile COC which could impact ground water to the west of the Site in the downgradient flow direction toward the East Fork of the Whitewater River. In addition, institutional controls will be implemented to limit future land use and provide proscriptive measures for future construction workers should they encounter residuals while conduction improvements to the property.

6.2 Site Capping

6.2.1 Site Preparation

It is anticipated that much of the Site preparation will be completed as part of the ongoing source removal activities at the Site. These activities include clearing and grubbing of vegetation over the COC-impacted areas of the site. It is possible that a limited amount of vegetation may require removal from the slope along the western edge of the property. If required, these clearing and grubbing activities will be completed with excavation equipment mobilized to the Site for cap placement activities. Cleared and grubbed vegetation will be chipped and mulched on-site using a trailer-mounted chipping machine. All mulched material will be stockpiled on-site to await use as cap cover in areas that do not require seeding.

Site preparation activities will also include any remaining Site grading that was not completed during source removal activities. Generally, the anticipated slope is a 3:1 grade downslope to the western edge of the site. Any Site grade that does not meet this slope requirement will be made to do so prior to capping activities utilizing the hydraulic equipment mobilized to the Site for cap installation.

One exception to the 3:1 grade requirement will be the base of the access road to be installed by the City of Richmond across the Site. The grade of this roadway will be provided by the City prior to mobilization and this roadway requirement will be incorporated into the Site grading plan.

6.2.2 Cap Installation

Once the Site has been graded, cap installation activities will be initiated. The general outline of the anticipated cap is included on **Figure 14**. Prior to approval for use, a sample of the proposed clay cap material will be collected from a local source of choice, delivered to an environmental/ geotechnical laboratory and analyzed for concentrations of COC (BTEX and PAHs) as well as proctor testing to ensure adequate compaction qualities of the clay. Assuming that the selected clay material does not contain detectable concentrations of COC and possesses adequate compaction characteristics, this material will be approved for use as the cap for the Site.

Following approval, clay fill will be transported to the Site from the selected local source by dump trucks. This material will be unloaded and spread across the Site with a track-mounted hydraulic excavator and front-end loader. Depending upon the compaction characteristics of the proctor analysis, approximately 4,600 tons of clay will be spread across the Site to a thickness of approximately 24 inches, with the exception of the area of the proposed City roadway. This clay cap material will then be compacted to 95% of the proctor value determined from geotechnical laboratory testing to a compacted thickness of 18 inches.

The uncapped area designated for the roadway will be backfilled using base material to be specified by the City of Richmond.

6.3 Site Restoration

Site restoration will commence following the completion of capping activities. Approximately 1,500 tons of topsoil will be placed over the compacted clay. The newly placed topsoil will be hydro-seeded to facilitate growth of grass. Any areas of the Site not capped and/or seeded will be covered with the stockpiled mulch material. The proposed City roadway across the Site will be completed with asphalt surface tied into the clay cap. The completion of the roadway will mark the completion of the Site capping activities.

6.4 Ground Water Remediation

As noted above, the selected remedial approach to address COC-impacted ground water to the west of the Site is a combination of in-situ chemical oxidation and biodegradation injections. Due to cost and reactivity considerations, chemical oxidation agents provided by Regenesis of San Clemente, California have been selected for this project in lieu of other conventional agents such as Fenton's reagent and high-concentration hydrogen peroxide. A brief summary of the selected Regenesis agents is presented below followed by injection and progress monitoring procedures.

The Regenesis agent RegenOx© is proposed to rapidly and effectively destroy COC within the saturated zone west of the Site. RegenOx© produces a cascade of oxidation reactions via a number of mechanisms including: surface mediated oxidation, direct oxidation, and free radical oxidation. COC reduction will be the result of the powerful desorption-surfactant like effect of RegenOx© (principally the catalyst) that draws the contaminant off of the soil surface and into the solution. The contaminant then reaches the catalytic surface where localized free-radical generation occurs leading to focused and efficient contaminant destruction. These reactions can be propagated in the presence of RegenOx© for periods of up to 30 days following a single injection.

RegenOx© produces minimal heat and is highly compatible with supplemental enhanced biodegradation application. Additionally RegenOx© is a powerful and relatively safe chemical oxidant that is safe for use in direct contact with underground utilities/infrastructure as it is non-corrosive and produces very low amounts of heat and pressure.

RegenOx© application will produce oxygen as a result of its reactions providing an advantageous and seamless transition from in-situ chemical oxidation to enhanced aerobic biodegradation by Oxygen Release Compound (ORC®) application. ORC is a formulation of intercalated magnesium peroxide that, when hydrated, will produce a controlled release of oxygen. ORC® supplies controlled-release molecular oxygen to the subsurface environment where it will accelerate the rate of naturally occurring aerobic contaminant biodegradation in ground water and saturated soils for periods of up to 12 months beyond a single application.

6.4.1 Injection Procedure

RegenOx© and ORC® application will destroy and reduce significant quantities of COC from the subsurface (both soil and ground water) and will be applied using direct-injection techniques. Three (3) injection events are planned for this remedial program, spaced at 120 day intervals. The initial two injection events will include the application of RegenOx© only. For the third injection event, ORC® will be mixed with Regenox©. In each case, these materials will be mixed with water to form an injectable slurry which will then be pressure injected into the zone of contamination. Once in the aquifer, ORC© particles can sorb to and/or reside in the soil matrix and produce a controlled-release of oxygen for periods of up to 12 months beyond a single application.

The area of concern for the injections is located to the west of the northwest corner of the Site, as shown in **Figure 15**. Approximately 180 injection points will be advanced on 10 foot centers within the treatment area from 18 feet bgs to 23 feet bgs, as determined by previous Site investigations.

During each of the first two injection events, 11,300 pounds (lbs.) of RegenOx© will be injected at the 180 points in the impacted area. The Regenox© will be delivered to the Site in powder form in 28 drums, each containing 400 lbs of RegenOx©. Approximately 670 lbs of Regenox will be mixed with water in 1,000 gallon batches in an appropriately-sized mixing tank. At the required injection volume of 94 gallons per point, this will provide sufficient slurry for injection into 10 points. The injection will be completed using a high pressure pump and direct push drilling equipment. It is anticipated that this mixing process will be completed twice per day and that 20 injections will be completed each work day. As a result, it is anticipated that each of the first two RegenOx© events will be completed in 10 work days, which includes one day for equipment mobilization and setup.

During the third injection event, 11,300 lbs of RegenOx© and 6,750 lbs of ORC© will be injected amongst the 180 points within the impacted area. The ORC© will be delivered to the Site in powder form in 27 fiber drums, each containing 250 lbs of ORC©. Approximately 350 lbs of ORC © will be mixed with 670 lbs of RegenOx© and water in batches of 1,000 gallons in an appropriately-sized mixing tank. At the same required injection volume of 94 gallons per point, this will provide sufficient slurry for 20 injections per work day and an anticipated completion of this third event in 10 work days, including one day for mobilization.

The direct push equipment and high pressure pump will be decontaminated prior to initiating field activities, at the completion of each work day, and immediately following the completion of each injection event using a high-pressure spray to remove contaminants and residual injection slurry. Decontamination rinsate water will be collected in DOT-approved 55-gallon open-top steel drums staged at the Site to await characterization and disposal. All field activities are anticipated to be completed using Level D personal protective equipment as specified in the attached Site-specific Health and Safety Plan (HASP) (see **Appendix E**).

6.4.2 Progress Monitoring

In order to monitor the remedial progress and reduction in COC mass, a ground water monitoring program will be part of the Site remedial activities. As noted above, the injection events will be spaced at 120 day intervals to allow for RegenOx© and ORC© curing time and to accomodate quarterly ground water monitoring during the injection program. A detailed description of Site ground water monitoring procedures and analytical requirements is included in Section 7.0.

The first ground water monitoring event will take place immediately prior to the initial injection event. Laboratory analytical data generated during this monitoring event will be used as a baseline for comparison of remedial effectiveness and progress. The second ground water monitoring event will take place approximately 90 days following the completion of the initial injection event. Laboratory analytical data from this monitoring event will be compared to the baseline levels to determine the reduction in COC from the initial injection event. A third and fourth groundwater monitoring event will take place approximately 90 days after the completion of the second and third injection events, respectively.

Assuming that progressive COC reduction is documented during these 4 ground water monitoring events, these events will be considered the initial 4 of the required eight (8) ground water monitoring events required to secure Site closure.

7.0 Monitoring and Sampling Plan

As noted above, ground water samples will be collected quarterly for eight quarters to document reduced concentrations of COC and to demonstrate mass contaminant reduction at the Site. Assuming that the in-situ chemical oxidation and biodegradation injection program is successful in progressively reducing COC concentrations in the ground water, the 4 monitoring events associated with the injection program will constitute the initial 4 of the required 8 ground water monitoring events required to secure Site closure. The following sections describe the ground water sampling activities and procedures to be completed during the quarterly sampling events.

7.1 Quarterly Ground Water Sampling

During each quarterly ground water sampling event, all monitoring wells within the Site network will be purged and sampled using low flow methods. Water level measurements will also be recorded to calculate the volume of water present, assess accumulation of fine-grained sediments, and evaluate the direction of ground water flow.

7.1.1 Sampling Procedures

Water level measurements will be measured with an oil-water interface meter with an accuracy of 0.01 foot. The ground water will be purged using a submersible pump capable of low flow methods. Additionally, new low-density polyethylene tubing and conducted at a flow rate sufficient to remove fine-grained sediment from the well while minimizing drawdown of the water level within the well. During the purging process, ground water elevations and physical parameters including pH, conductivity, oxidation-reduction potential, temperature, dissolved oxygen, and turbidity will be measured and recorded until stabilization of all parameters has been achieved. Stabilization will be considered achieved when consecutive readings of all physical parameters are within 10%.

Once stabilization has occurred, ground water samples will be collected using laboratory-supplied sample media and submitted to an off-site laboratory for analysis. Purge water generated during each sampling event will be stored in DOT-approved 55-gallon open top steel drums staged at the Site pending disposal. If free product is detected in any monitoring well, it will be removed using a peristaltic pump or disposable polyethylene bailer and placed in a DOT-approved 55-gallon open-top steel drum staged at the Site pending disposal.

7.1.2 Decontamination

Decontamination of all non-disposable ground water sampling equipment will occur following sample collection at each monitoring well using a phosphate-free detergent wash and a distilled water rinse. Decontamination water generated during each sampling event will be stored in DOT-approved 55-gallon open top steel drums staged at the Site pending disposal.

7.1.3 Sample Shipment and Analysis

Samples will be placed in laboratory-supplied sample coolers containing ice and delivered under standard chain-of-custody procedures to Pace Analytical Services, Inc. located in Indianapolis, Indiana for analysis of BTEX, PAHs, RCRA metals, total iron, and total and WAD cyanide. Ferrous iron concentrations will be measured immediately following sample collection using a Hach® ferrous iron test kit.

7.1.4 Data Management

Field personnel will adhere to the safety protocols outlined in the Site-specific HASP (**Appendix E**). Field observations and data will be collected in accordance with the procedures established in the Site-specific Quality Assurance Project Plan (**Appendix F**).

Brief letter reports summarizing the activities, findings, problems or potential problems, actions taken or actions needed to be taken, and laboratory analytical results will be prepared and submitted following each ground water sampling event.

8.0 Operation and Maintenance

No remediation systems are proposed in this RAWP. Therefore, no operation and/or maintenance procedures are required; however, it is recommended that monitoring well MW-001 be gauged on a monthly basis for a minimum of 3 months to ensure the absence of LNAPL accumulation following the completion of the source removal program outlined in the approved Removal Action Work Plan (AECOM, 2011).

9.0 Reporting

9.1 Completion Report

An interim completion report will be prepared following the completion of the 3 injection events and the initial 4 ground water sampling events to document the effectiveness of the injection program. The completion report will summarize the performance of the injections, the extent to which COC reduction has occurred, and the results of the associated ground water monitoring.

9.2 Progress Reports / Monitoring Reports

As noted above in Section 7.1.4, brief letter reports summarizing the activities, findings, problems or potential problems, actions taken or actions needed to be taken, and laboratory analytical results will be prepared and submitted following each ground water sampling event.

10.0 Projected Work Schedule

Project fieldwork is anticipated to begin in the winter of 2012/2013. Assuming that the initial monitoring and injection events occur in February 2013, the second injection event will occur in June 2013 and the third injection event will occur in October 2013. The fourth ground water sampling event will occur in September 2013. Assuming that adequate Site remediation is demonstrated by the results of the first 4 ground water sampling events and the final 4 ground water sampling events are completed approximately 90 days apart, the final ground water sampling event will be completed in September 2014. A Site Closure Report will be prepared and issued within 60 days of final receipt of analytical data (November 2014).

11.0 Cost Estimate

The total estimated cost to implement the activities in this RAWP is $719,000. This cost includes $262,000 for Site capping, $243,000 for three RegenOx© injection events, $72,000 for one ORC© injection event, $80,000 for 8 ground water sampling events, and $62,000 for project management and reporting.

12.0 References

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Tables

Table 1
Sample Collection and Analyses Summary - Pre-2012 Investigation Data
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Investigation/Documentation	Activities Completed				Samples Collected				Analyses
	Soil Boring	Test Pitting	Well Installation	Slug Testing	Surface Soil	Subsurface Soil	Ground Water	TOC in H20	
RETEC, 1994. Preliminary Assessment, Former Manufactured Gas Plant Site, Richmond, Indiana. August 15, 1994 [PA].									
RETEC, 1995a. Site Inspection Report, Former Manufactured Gas Plant Site, Richmond, Indiana. March 31, 1995 [SI]	16		4			34 (including 3 duplicates)	5 (including 1 duplicate)	5 (including 1 duplicate)	VOCs, SVOCs, total cyanide
RETEC, 1995b. Slug Testing Report, Site Inspection, Former Manufactured Gas Plant Site, Richmond, Indiana. March 31, 1995.				4					
RETEC, 1996a. Additional Site Investigation Report, Former Manufactured Gas Plant Site, Richmond, Indiana. January 12, 1996.	2		2			5 (including 1 duplicate)	3 (including 1 duplicate)		BTEX, PAHs, total cyanide
RETEC, 1996b. Surface Soil Sampling Report, Former Manufactured Gas Plant Site, Richmond, Indiana. May 31, 1996	12				14 (including 1 duplicate)				BTEX, PAHs, total cyanide
(RETEC, 1996c). Ground Water Monitoring Summary, April 1996, Former Manufactured Gas Plant, Richmond, Indiana. June 21, 1996							3 (including 1 duplicate)		BTEX, PAHs, total cyanide
(RETEC, 2005c). Remediation Completion Report, Purifier Parcel – Richmond MGP, Richmond, Indiana. August 18, 2005.		3							
Burgess & Niple, 2007. Supplemental Subsurface Investigation, Former Manufactured Gas Plant, Richmond, Indiana. April 20, 2007. [SI]	7	2	2		6	2			BTEX, PAHs, total cyanide, and metals
Keramida Inc., 2011. Phase II Investigation Report, Former Manufactured Gas Plant, 77 Johnson Street, Richmond, Indiana. June 11, 2011.	15		1		33 (including 3 duplicates)	7 (including 1 duplicate)	6 (including 1 duplicate)		BTEX, PAHs, WAD cyanide, and metals

AECOM

Table 2
Subsurface Soil Analytical Results - August 2012
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Sample ID Sample Interval Sample Date	RISC Residential Default Closure Level	RISC Industrial Default Closure Level	SB-12-02 24-26 7/31/2012	MW-015 22-23 8/17/2012	MW-015 23-25 8/17/2012
BTEX (mg/Kg)					
Benzene	0.034	0.35	**4.220**	**0.186J**	**0.795J**
Ethylbenzene	13	160	**18.800**	2.360	0.972
Toluene	12	240	8.270	<0.282	<0.282
Xylenes, Total	170	170	37.700	0.875	<0.570
PAHs (mg/Kg)					
2-Methylnaphthalene	16	210	**32.600**	0.909	1.140
Acenaphthene	130	1200	7.620	11.700	5.760
Acenaphthylene	18	180	11.700	3.120	0.744
Anthracene	51	51	13.200	6.630	2.710
Benzo(a)anthracene	5	15	**9.790**	4.070	1.300
Benzo(a)pyrene	0.5	1.5	**7.080**	**2.940**	**0.966**
Benzo(b)fluoranthene	5	15	4.770	1.270	0.463
Benzo(g,h,i)perylene	16	16	2.980	0.993	0.453
Benzo(k)fluoranthene	39	39	5.790	1.430	0.535
Chrysene	25	25	8.960	4.170	1.220
Dibenzo(a,h)anthracene	0.5	1.5	**1.700**	0.495	0.193
Fluoranthene	880	880	19.600	7.860	3.470
Fluorene	170	1100	13.200	4.310	2.680
Indeno(1,2,3cd)pyrene	3.1	3.1	2.780	0.829	0.344
Naphthalene	0.7	170	**96.200**	**1.440**	**1.600**
Phenanthrene	13	170	**43.400**	10.800	7.260
Pyrene	570	570	17.700	14.600	4.730
TOC (mg/Kg)					
Total Organic Carbon	NA	NA	6820	11200	15600

Notes:
RISC = Risk Integrated System of Closure
mg/kg = milligram per kiligram
J = Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit
< = denotes not detected, or value below detection limit
Yellow highlighted value exceeds RISC Residential Default Closure Level
Orange highlighted value exceeds RISC Industrial Default Closure Level

AECOM

Table 3
Monitoring Well Identification and Ground Water Elevations - August 2012
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

WELL IDENTIFICATION	TOC ELEVATION (feet above MSL)	DEPTH TO WATER (feet below TOC)	WATER ELEVATION (feet above MSL)	SCREENED INTERVAL (feet above MSL)	DEPTH TO BOTTOM (feet below TOC)	DEPTH TO NAPL (feet below TOC)	NAPL THICKNESS (feet)
MW-001	903.16	13.48	889.68	886.32 - 876.32	25.77	12.29	1.19
MW-006	920.40	14.78	905.62	913.40 - 903.40	16.05	--	--
MW-008	901.31	19.55	881.76	885.31 - 865.31	33.53	--	--
MW-010	899.05	17.62	881.43	883.26 - 873.26	25.63	--	--
MW-011	898.89	18.13	880.76	883.015 - 873.015	25.86	--	--
MW-012S	900.14	NA	NA	891.663 - 881.663	18.66	--	--
MW-012D	900.33	18.64	881.69	890.414 - 870.414	26.18		
MW-013	901.98	NA	NA	891.98 - 881.98	19.70	--	--
MW-014	934.79	NA	NA	920.828 - 925.828	8.77	--	--
MW-015	899.67	17.85	881.82	889.999 - 874.999	24.53		
MW-101	901.55	20.86	880.69	889.45 - 879.45	22.14	--	--
MW-102	900.21	19.56	880.65	889.40 - 879.40	21.69	--	--

Notes:
TOC = top of PVC well casing
MSL = mean sea level
NAPL = non-aqueous phase liquid
S = Shallow
D = Deep
NA = not available or not applicable
MW-12D and MW-15 were installed after the August 2012 gauging event
MW-12, MW-13, and MW-14 did not contain water during the August 2012 gauging event

Table 4
Water Quality Parameters - August 2012
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Sample ID **Sample Date**	**MW-006** **8/2/2012**	**MW-008** **8/2/2012**	**MW-010** **8/1/2012**	**MW-011** **8/2/2012**	**MW-012D** **8/17/2012**	**MW-015** **8/17/2012**	**MW-101** **8/2/2012**	**MW-102** **8/1/2012**
Physical Parameters								
Volume Removed [gallons]	0.75	1.25	5.0	4.0	5.0	3.0	1.0	2.5
Temperature [^oC]	NA	15.58	15.01	16.38	16.84	16.37	18.99	14.76
Conductivity [mS/cm]	NA	2263	604	1589	1226	1151	1702	874
Dissloved Oxygen [mg/L]	NA	0.61	1.10	0.30	0.18	0.39	0.84	0.86
pH [S.U.]	NA	6.59	6.98	6.74	6.76	6.88	6.47	6.55
ORP [mV]	NA	-101.8	-87.0	-107.7	-71.8	-57.7	-49.1	-25.1
Turbidity [NTU]	NA	2.06	81.3	16.1	44.1	33.4	3.04	2.63

Notes:
^oC = Celsius
S.U. = Standard Units
mS/cm = milli-siemens per centimeter
mg/L = milligram per liter
mV = millivolts
NTU = nephelometric turbidity units
NA = not available, water quality measurements not taken at MW-006 due to the presence of free product globules

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Table 5
Summary of Sample Analyses - August 2012
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Media	# of Samples	# of Duplicates	# of Trip Blanks	Analytes	SW-846 Analytical Method (b)	DQO Level (c)
Ground Water	6	2	1(a)	BTEX (d) PAH (e) + 2-MN Cyanide, Total RCRA Metals (f) + Iron, Total and Ferrous	8260B 8270 SIM 335.4 6010, 7470A	III
Soil	2	0	0	BTEX (d) PAH (e) + 2-methylnaphthalene Total Organic Carbon Porosity, Grainsize and Permeability	8260B 8270 SIM LVE Walkley Black	III

Notes:
(a) A trip blank accompanied each cooler containing BTEX samples
(b) "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", USEPA SW-846, 3rd Edition, June 1997
(c) DQO = Data quality objective level
(d) BTEX compounds: benzene, toluene, ethylbenzene, and xylene
(e) PAH (polynuclear aromatic hydrocarbons) compounds: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthe
benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and p
(f) RCRA Metals include: arsenic, barium, cadmium, chromium, iron, lead, mercury, selenium, and silver

Table 6
Ground Water Analytical Results - August 2012
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Sample ID Sample Date	RISC Residential Default Groundwater Level	RISC Industrial Default Groundwater Level	MW-006 8/2/2012	MW-008 8/2/2012	MW-010 8/1/2012	MW-011 8/2/2012	DUP-01 MW-011 8/2/2012	MW-012D 8/17/2012	MW-015 8/17/2012	MW-101 8/2/2012	MW-102 8/1/2012
BTEX (mg/L)											
Benzene	0.005	0.052	**0.966**	<0.005	<0.005	<0.005	<0.005	**0.0732**	**0.04**	<0.005	<0.005
Ethylbenzene	0.7	10	**0.741**	<0.005	<0.005	0.0086	0.0097	0.0991	0.051	<0.005	<0.005
Toluene	1	8.2	0.0513	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Xylenes, Total	10	20	0.411	<0.010	<0.010	<0.010	<0.010	0.0281	0.0181	<0.010	<0.010
PAHs (mg/L)											
2-Methylnaphthalene	0.031	0.41	**0.0433**	<0.0010	<0.001	0.0063	0.0063	**0.0456**	**0.034**	<0.0010	<0.0010
Acenaphthene	0.46	6.1	<0.001	0.0178	<0.001	0.0783	0.0775	0.0651	0.249	0.0479	0.0096
Acenaphthylene	0.071	0.73	0.0038	<0.0010	<0.001	0.0033	0.0034	0.027	0.0211	0.0017	<0.0010
Anthracene	2.3	31	0.012	0.00012	<0.0001	0.0063	0.0064	0.0205	0.0309	0.00074	0.00011
Benzo(a)anthracene	0.0012	0.0039	**0.0045**	<0.00010	<0.0001	0.00036	0.00044	**0.0062**	**0.0105**	<0.00010	<0.00010
Benzo(a)pyrene	0.0002	0.00039	**0.0042**	<0.00010	<0.0001	0.00012	**0.0002**	**0.0052**	**0.0083**	<0.00010	<0.00010
Benzo(b)fluoranthene	0.0012	0.0039	**0.0019**	<0.00010	<0.0001	<0.0001	<0.0001	**0.0023**	**0.0036**	<0.00010	<0.00010
Benzo(g,h,i)perylene	NA	NA	0.0023	<0.00010	<0.0001	<0.0001	<0.0001	0.0024	0.0033	<0.00010	<0.00010
Benzo(k)fluoranthene	0.012	0.039	0.0026	<0.00010	<0.0001	<0.0001	0.00014	0.003	0.0043	<0.00010	<0.00010
Chrysene	0.12	0.39	0.0045	<0.00050	<0.0005	<0.0005	<0.0005	0.0059	0.01	<0.00050	<0.00050
Dibenzo(a,h)anthracene	0.00012	0.00039	**0.00071**	<0.00010	<0.0001	<0.0001	<0.0001	**0.00069**	**0.0013**	<0.00010	<0.00010
Fluoranthene	1.5	4.1	0.0141	<0.0010	<0.001	0.0053	0.0057	0.0197	0.0274	<0.0010	<0.0010
Fluorene	0.31	4.1	0.0226	<0.0010	<0.001	0.0267	0.0275	0.0478	0.0703	0.003	<0.0010
Indeno(1,2,3cd)pyrene	0.0012	0.0039	**0.0015**	<0.00010	<0.0001	<0.0001	<0.0001	**0.0017**	**0.0025**	<0.00010	<0.00010
Naphthalene	0.0083	2	**0.357**	<0.0010	<0.001	**0.0374**	**0.0372**	**0.261**	**0.193**	<0.0010	<0.0010
Phenanthrene	0.023	0.31	**0.0436**	<0.0010	<0.001	**0.0269**	**0.0273**	**0.0385**	**0.122**	<0.0010	<0.0010
Pyrene	1.1	3.1	0.0196	<0.0010	<0.001	0.0061	0.0065	0.0301	0.0404	0.001	<0.0010
RCRA Metals (mg/L)											
Arsenic	0.01	0.01	<0.0100	<0.0100	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0100	<0.0100
Barium	2	20	0.16	0.256	0.131	0.195	0.197	0.244	0.242	0.208	0.178
Cadmium	0.005	0.051	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050
Chromium*	0.1	0.31	<0.0100	<0.0100	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0100	<0.0100
Iron	NA	NA	2.05	2.75	0.904	0.933	0.942	1.7	2.39	1.15	2.53
Lead	0.015	0.042	<0.0100	<0.0100	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0100	<0.0100
Selenium	0.05	0.51	<0.0100	<0.0100	<0.010	<0.010	0.0112	<0.0100	<0.0100	<0.0100	<0.0100
Silver	0.18	0.51	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500
Iron, Ferrous	NA	NA	<0.00020	2.0	0.1	1.1	1.1	<0.1	0.7	0.1	1.9
Mercury	0.002	0.031	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Cyanide (mg/L)											
Cyanide, Total	0.2	2	**2.6**	0.13	<0.010	<0.010	<0.010	0.14	**0.23**	<0.010	0.038

Notes:

RISC = Risk Integrated System of Closure
NA = Not Applicable
< = denotes not detected, or value below detection limit
mg/L = milligram per liter
* - Samples analyzed for 'Total Chromium' and compaired against Chromium III / VI RISC Default Level of 0.31 mg/L
Yellow highlighted value exceeds RISC Residential Default Groundwater Level
Orange highlighted value exceeds RISC Industrial Default Groundwater Level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site **Sample ID** **Date** **Depth (ft)** **CONSTITUENT**	**CWDC**	**RNCL**	**BNTP-04** **BNTP-4** **1/29/2007** **0** **Primary**	**BNTP-04S** **BNTP-4S** **1/29/2007** **0** **Primary**	**BNTP-05** **BNTP-5** **1/29/2007** **0** **Primary**	**MW-001** **SB/MW-1** **10/1/1994** **14** **Primary**	**MW-001** **SB/MW-1** **10/1/1994** **22** **Primary**	**MW-001** **SB/MW-1** **10/1/1994** **22** **Duplicate 1**	**MW-002** **SB/MW-2** **10/1/1994** **4** **Primary**	**MW-002** **SB/MW-2** **10/1/1994** **14** **Primary**	**MW-003** **SB/MW-3** **10/1/1994** **10** **Primary**	**MW-003** **SB/MW-3** **10/1/1994** **16** **Primary**
BTEX (mg/Kg)												
Benzene	560	14	<0.0056	<0.0063	<0.0063	<1.4	<0.39	<0.36	<0.34	2.3	0.39	<1.6
Ethylbenzene	29000	160	<0.0056	<0.0063	<0.0063	20	2.5	2.6	<0.34	3.4	<0.39	10
Toluene	49000	310	<0.0056	<0.0063	<0.0063	<1.4	<0.39	<0.36	<0.34	3.4	0.55	3.2
Xylenes, Total	4800	170	<0.0056	<0.0063	<0.0063	16	2.2	2.1	<0.34	5.9	<0.39	17
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	0.0687	<0.062	<0.064	110	25	140	<3.7	20	<0.82	45
Acenaphthylene	5900	2800	0.497	0.12	0.0903	<39	<4.2	<39	<3.7	<19	<0.82	<17
Anthracene	250000	6000	0.589	0.062	<0.064	45	10	50	<3.7	<19	<0.82	47
Benzo(a)anthracene	790	5.1	1.66	0.124	0.177	[<39]	**[7.1]**	[<39]	<3.7	[<19]	3.2	**[41]**
Benzo(a)pyrene	79	0.51	**[1.43]**	0.142	0.248	[<39]	**[6.7]**	[<39]	[<3.7]	[<19]	**[2.9]**	**[29]**
Benzo(b)fluoranthene	790	5.1	1.03	0.0948	0.192	[<39]	**[5.1]**	[<39]	<3.7	[<19]	3.8	**[30]**
Benzo(g,h,i)perylene	NA	NA	0.697	0.0802	0.184	<39	4.3	<39	<3.7	<19	2	<17
Benzo(k)fluoranthene	7900	51	1.07	0.0985	0.2	<39	<4.2	<39	<3.7	<19	1.1	<17
Chrysene	79000	510	1.66	0.128	0.192	<39	6.2	<39	<3.7	<19	2.6	32
Dibenz(a,h)anthracene	79	0.51	0.291	<0.062	<0.064	[<39]	[<4.2]	[<39]	[<3.7]	[<19]	[<0.82]	[<17]
Fluoranthene	33000	6000	2.37	0.182	0.211	66	16	65	<3.7	30	4.2	83
Fluorene	33000	6000	0.298	<0.062	<0.064	45	12	52	<3.7	32	<0.82	59
Indeno(1,2,3-cd)pyrene	790	5.1	0.599	0.0657	0.154	[<39]	<4.2	[<39]	<3.7	[<19]	1.8	[<17]
Naphthalene	17000	6000	0.137	0.0657	<0.064	190	47	260	<3.7	210	<0.82	220
Phenanthrene	2500	1200	2.24	0.153	0.113	180	47	210	<3.7	120	<0.82	180
Pyrene	25000	6000	2.89	0.193	0.23	140	<4.2	130	<3.7	51	4.1	100
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	10000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	450	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	650	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	260	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	77.9	<0.157	3.63	<0.74	6.2	0.96	<0.28	<0.29	0.59	18
Cyanide, WAD	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

AECOM

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	MW-004 SB/MW-4 (14-16) 10/20/1994 16 Primary	MW-004 SB/MW-4 (20-22) 10/20/1994 22 Primary	MW-004 SB/MW-4 (20-22) 10/20/1994 22 Duplicate 1	MW-005 MW-5 1/29/2007 2 Primary	MW-005 MW-5 1/29/2007 12 Primary	MW-006 MW-6 1/29/2007 2 Primary	MW-006 MW-6 1/29/2007 10 Primary	MW-007 MW-7 1/29/2007 2 Primary	MW-101 SB/MW-101 10/9/1995 10 Primary	MW-101 SB/MW-101 10/9/1995 10 Duplicate 1
BTEX (mg/Kg)												
Benzene	560	14	<0.35	<3.9	<0.34	<0.0062	0.031	<0.0062	[19.8]	<0.0053	<0.36	<0.36
Ethylbenzene	29000	160	<0.35	12	<0.34	<0.0062	1.06	<0.0062	119	<0.0053	<0.36	<0.36
Toluene	49000	310	<0.35	<3.9	<0.34	<0.0062	<0.0131	<0.0062	6.95	<0.0053	<0.36	<0.36
Xylenes, Total	4800	170	<0.35	11	<0.34	<0.0062	0.201	<0.0062	109	<0.0053	<0.36	<0.36
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	<24	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	<3.8	56	<3.6	0.177	1.96	<0.0635	90	<0.0533	<0.39	<0.38
Acenaphthylene	5900	2800	<3.8	26	<3.6	0.331	0.0932	1.37	18.9	<0.0533	<0.39	<0.38
Anthracene	250000	6000	<3.8	48	7	0.177	0.974	0.385	81.8	<0.0533	<0.39	<0.38
Benzo(a)anthracene	790	5.1	<3.8	[38]	[10]	0.421	0.519	1.3	[62.8]	0.0784	<0.39	<0.38
Benzo(a)pyrene	79	0.51	[<3.8]	[29]	[6.5]	0.41	0.482	0.467	[71.6]	0.0659	<0.39	<0.38
Benzo(b)fluoranthene	790	5.1	<3.8	[26]	[8.2]	0.448	0.201	1.22	[30.7]	0.0533	<0.39	<0.38
Benzo(g,h,i)perylene	NA	NA	<3.8	<24	<3.6	0.482	0.202	1.38	38.7	<0.0533	<0.39	<0.38
Benzo(k)fluoranthene	7900	51	<3.8	<24	<3.6	0.467	0.294	1.42	45	0.0565	<0.39	<0.38
Chrysene	79000	510	<3.8	29	7.7	0.493	0.479	1.65	61.2	0.0565	<0.39	<0.38
Dibenz(a,h)anthracene	79	0.51	[<3.8]	[<24]	[<3.6]	0.102	0.0595	0.321	[10.3]	<0.0533	<0.39	<0.38
Fluoranthene	33000	6000	<3.8	77	20	0.719	1.22	1.91	167	0.122	<0.39	<0.38
Fluorene	33000	6000	<3.8	51	4.1	0.132	0.97	0.183	62.6	<0.0533	<0.39	<0.38
Indeno(1,2,3-cd)pyrene	790	5.1	<3.8	[<24]	<3.6	0.35	0.157	1.04	[27.7]	<0.0533	<0.39	<0.38
Naphthalene	17000	6000	<3.8	320	<3.6	0.241	0.161	0.306	488	<0.0533	<0.39	<0.38
Phenanthrene	2500	1200	<3.8	180	27	0.5	0.399	0.815	269	0.0627	<0.39	<0.38
Pyrene	25000	6000	<3.8	99	15	0.88	1.72	3.04	210	0.107	<0.39	<0.38
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	9.72	NA	7.69	NA	[22.1]	NA	NA
Barium	220000	10000	NA	NA	NA	70.1	NA	51.7	NA	109	NA	NA
Cadmium	590	450	NA	NA	NA	<6.06	NA	<6.43	NA	<5.35	NA	NA
Chromium	3400	650	NA	NA	NA	14.2	NA	8.98	NA	12.2	NA	NA
Lead	970	400	NA	NA	NA	44.9	NA	32.1	NA	42.2	NA	NA
Mercury	340	260	NA	NA	NA	0.0505	NA	0.0746	NA	0.0617	NA	NA
Selenium	5700	4300	NA	NA	NA	<20.2	NA	<21.4	NA	<17.8	NA	NA
Silver	5700	4300	NA	NA	NA	<0.63	NA	<0.636	NA	<0.508	NA	NA
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	<0.15	0.44	<0.27	12.4	0.241	73.2	92	<0.134	<0.15	<0.15
Cyanide, WAD	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

AECOM

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	MW-101 SB/MW-101 10/9/1995 18 Primary	MW-101 SB/MW-101 10/9/1995 20 Primary	MW-102 SB/MW-102 10/10/1995 10 Primary	MW-102 SB/MW-102 10/10/1995 20 Primary	MW-102 SB/MW-102 10/10/1995 20 Primary	SB-005 SB-5 (6-8) 10/21/1994 8 Primary	SB-007 SB-7 10/1/1994 10 Primary	SB-007 SB-7 10/1/1994 14 Primary	SB-009 SB-9 (2-4) 10/20/1994 4 Primary	SB-009 SB-9 (4-6) 10/20/1994 6 Primary
BTEX (mg/Kg)												
Benzene	560	14	<0.34	NA	<0.36	<0.34	NA	<0.33	1.2	<0.39	<0.35	<0.37
Ethylbenzene	29000	160	<0.34	NA	<0.36	<0.34	NA	<0.33	4.8	18	<0.35	<0.37
Toluene	49000	310	<0.34	NA	<0.36	<0.34	NA	<0.33	3.1	<0.39	<0.35	<0.37
Xylenes, Total	4800	170	<0.34	NA	<0.36	<0.34	NA	<0.33	4.4	4.2	<0.35	<0.37
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	<0.35	NA	NA	4.1	3.7
Acenaphthene	50000	6000	19	NA	<0.38	<0.36	NA	<0.35	<4.1	92	6.9	6.2
Acenaphthylene	5900	2800	2.6	NA	<0.38	<0.36	NA	<0.35	4.1	<20	9.2	7.8
Anthracene	250000	6000	10	NA	0.45	<0.36	NA	<0.35	<4.1	61	14	12
Benzo(a)anthracene	790	5.1	[7]	NA	1.9	<0.36	NA	<0.35	4.6	[35]	[14]	[11]
Benzo(a)pyrene	79	0.51	[5]	NA	[2.2]	<0.36	NA	<0.35	[8.4]	[49]	[7]	[6.5]
Benzo(b)fluoranthene	790	5.1	3.6	NA	2	<0.36	NA	<0.35	[10]	[39]	[8.5]	[8]
Benzo(g,h,i)perylene	NA	NA	2.4	NA	1.3	<0.36	NA	<0.35	16	29	3.8	3.8
Benzo(k)fluoranthene	7900	51	<1.8	NA	0.69	<0.36	NA	<0.35	<4.1	<20	3.1	<3.1
Chrysene	79000	510	6	NA	1.5	<0.36	NA	<0.35	<4.1	32	10	8.6
Dibenz(a,h)anthracene	79	0.51	[<1.8]	NA	<0.38	<0.36	NA	<0.35	[<4.1]	[<20]	[<3]	[<3.1]
Fluoranthene	33000	6000	10	NA	2.3	<0.36	NA	<0.35	10	100	22	19
Fluorene	33000	6000	13	NA	<0.38	<0.36	NA	<0.35	<4.1	46	19	17
Indeno(1,2,3-cd)pyrene	790	5.1	<1.8	NA	0.77	<0.36	NA	<0.35	[11]	[31]	3.5	3.4
Naphthalene	17000	6000	<1.8	NA	<0.38	<0.36	NA	<0.35	<4.1	140	4.8	4.4
Phenanthrene	2500	1200	25	NA	2.2	<0.36	NA	<0.35	7	210	44	39
Pyrene	25000	6000	22	NA	5.5	0.54	NA	<0.35	6	96	20	19
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	10000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	450	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	650	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	260	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	<0.55	<0.15	<0.58	<0.14	<0.57	<0.14	46	14	<0.15	<0.15
Cyanide, WAD	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level
[21] Reported above RNCL
[21] Reported above RNCL and CWDC
[<84] Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	SB-010 SB-10 10/1/1994 10 Primary	SB-010 SB-10 10/1/1994 16 Primary	SB-013 SB-13 10/1/1994 22 Primary	SB-014 SB-14 (6-8) 10/21/1994 8 Primary	SB-014 SB-14 (14-16) 10/21/1994 16 Primary	SB-016 SB-16 (6-8) 10/24/1994 8 Primary	SB-016 SB-16 (6-8) 10/24/1994 8 Duplicate 1	SB-016 SB-16 (12-14) 10/24/1994 12 Primary	SB-017 SB-17 (2-4) 10/18/1994 4 Primary	SB-017 SB-17 (4-6) 10/18/1994 6 Primary
BTEX (mg/Kg)												
Benzene	560	14	0.63	11	[14]	<0.39	<0.39	<0.34	<0.35	0.35	<0.36	<0.36
Ethylbenzene	29000	160	0.72	<3.4	<4.5	<0.39	<0.39	<0.34	<0.35	<0.35	<0.36	<0.36
Toluene	49000	310	1.7	12	26	<0.39	<0.39	<0.34	<0.35	<0.35	<0.36	<0.36
Xylenes, Total	4800	170	4.5	16	38	<0.39	<0.39	<0.34	<0.35	<0.35	<0.36	<0.36
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	5.2	NA	NA
Acenaphthene	50000	6000	<3.8	<18	<96	<42	4.8	<0.36	<0.38	<0.72	<0.39	<0.38
Acenaphthylene	5900	2800	<3.8	22	220	<42	4.4	<0.36	<0.38	<0.72	<0.39	<0.38
Anthracene	250000	6000	4	<18	230	<42	15	<0.36	<0.38	1.2	<0.39	<0.38
Benzo(a)anthracene	790	5.1	4.2	[<18]	[120]	[710]	[12]	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(a)pyrene	79	0.51	[<3.8]	[<18]	[<96]	[460]	[11]	<0.36	<0.38	[<0.72]	<0.39	<0.38
Benzo(b)fluoranthene	790	5.1	<3.8	[<18]	[<96]	[700]	[14]	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(g,h,i)perylene	NA	NA	<3.8	<18	<96	560	15	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(k)fluoranthene	7900	51	<3.8	<18	[<96]	[160]	<4.1	<0.36	<0.38	<0.72	<0.39	<0.38
Chrysene	79000	510	<3.8	<18	<96	[560]	12	<0.36	<0.38	<0.72	<0.39	<0.38
Dibenz(a,h)anthracene	79	0.51	[<3.8]	[<18]	[<96]	[84]	[<4.1]	<0.36	<0.38	[<0.72]	<0.39	<0.38
Fluoranthene	33000	6000	8.2	23	220	900	34	<0.36	<0.38	1.6	<0.39	<0.38
Fluorene	33000	6000	<3.8	<18	280	<42	11	<0.36	<0.38	0.94	<0.39	<0.38
Indeno(1,2,3-cd)pyrene	790	5.1	<3.8	[<18]	[<96]	[420]	[12]	<0.36	<0.38	<0.72	<0.39	<0.38
Naphthalene	17000	6000	32	130	1100	<42	<4.1	<0.36	<0.38	6.3	<0.39	<0.38
Phenanthrene	2500	1200	15	49	540	<42	41	<0.36	<0.38	<0.72	0.41	<0.38
Pyrene	25000	6000	10	31	190	990	30	<0.36	<0.38	<0.72	0.4	<0.38
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	10000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	450	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	650	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	260	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	0.22	<0.14	0.75	35	11	<0.14	<0.28	<0.27	0.33	<0.15
Cyanide, WAD	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	SB-018 SB-18 10/1/1994 4 Primary	SB-018 SB-18 10/1/1994 8 Primary	SB-019 SB-19 10/1/1994 4 Primary	SB-019 SB-19 10/1/1994 8 Primary	SB-020 SB-20 (2-4) 10/18/1994 4 Primary	SB-020 SB-20 (4-6) 10/18/1994 6 Primary	SB-020 SB-20 (6-7.7) 10/18/1994 7.7 Primary	SB-021 SB-21 10/1/1994 6 Primary	SB-021 SB-21 10/1/1994 10 Primary	SS-01 SS-1 4/3/1996 1 Primary
BTEX (mg/Kg)												
Benzene	560	14	0.46	<0.33	<0.34	<1.5	<0.36	0.4	<0.37	<0.39	<0.35	<0.41
Ethylbenzene	29000	160	<0.4	<0.33	<0.34	40	<0.36	<0.34	<0.37	<0.39	<0.35	<0.41
Toluene	49000	310	<0.4	<0.33	<0.34	<1.5	<0.36	<0.34	<0.37	<0.39	<0.35	<0.41
Xylenes, Total	4800	170	<0.4	<0.33	<0.34	35	<0.36	<0.34	<0.37	<0.39	<0.35	<0.41
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	<0.42	<0.35	<7.3	52	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Acenaphthylene	5900	2800	<0.42	<0.35	10	<48	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Anthracene	250000	6000	<0.42	<0.35	9.4	50	<0.77	8.5	<7.8	<4.1	<1.8	<0.43
Benzo(a)anthracene	790	5.1	<0.42	<0.35	**[20]**	**[58]**	<0.77	**[13]**	[<7.8]	<4.1	<1.8	0.49
Benzo(a)pyrene	79	0.51	<0.42	<0.35	**[16]**	[<48]	[<0.77]	**[8.4]**	[<7.8]	[<4.1]	[<1.8]	<0.43
Benzo(b)fluoranthene	790	5.1	<0.42	<0.35	**[16]**	[<48]	<0.77	**[12]**	[<7.8]	<4.1	<1.8	<0.43
Benzo(g,h,i)perylene	NA	NA	<0.42	<0.35	82	<48	<0.77	5	<7.8	<4.1	<1.8	<0.43
Benzo(k)fluoranthene	7900	51	<0.42	<0.35	<7.3	<48	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Chrysene	79000	510	<0.42	<0.35	20	56	<0.77	11	<7.8	<4.1	<1.8	0.71
Dibenz(a,h)anthracene	79	0.51	<0.42	<0.35	[<7.3]	[<48]	[<0.77]	[<3.6]	[<7.8]	[<4.1]	[<1.8]	<0.43
Fluoranthene	33000	6000	<0.42	<0.35	31	110	<0.77	33	<7.8	<4.1	<1.8	1.2
Fluorene	33000	6000	<0.42	<0.35	16	73	<0.77	4.4	<7.8	<4.1	<1.8	<0.43
Indeno(1,2,3-cd)pyrene	790	5.1	<0.42	<0.35	[<7.3]	[<48]	<0.77	4.6	[<7.8]	<4.1	<1.8	<0.43
Naphthalene	17000	6000	<0.42	<0.35	10	170	<0.77	7.4	<7.8	<4.1	<1.8	<0.43
Phenanthrene	2500	1200	<0.42	<0.35	79	340	<0.77	37	<7.8	<4.1	<1.8	0.74
Pyrene	25000	6000	<0.42	<0.35	71	210	<0.77	30	<7.8	<4.1	<1.8	1
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	10000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	450	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	650	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	260	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	<0.17	<0.14	1.9	1.2	4	3.5	0.27	<0.31	<0.15	<0.17
Cyanide, WAD	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	SS-01 SS-1 4/3/1996 2 Primary	SS-02 SS-2 (1-2) 4/3/1996 2 Primary	SS-03 SS-3 4/3/1996 1 Primary	SS-03 SS-3 4/3/1996 1 Duplicate 1	SS-04 SS-4 4/3/1996 0.5 Primary	SS-05 SS-5 4/3/1996 0.5 Primary	SS-06 SS-6 4/3/1996 0.5 Primary	SS-07 SS-7 4/3/1996 2 Primary	SS-08 SS-8 4/3/1996 1.5 Primary	SS-09 SS-9 4/3/1996 2 Primary
BTEX (mg/Kg)												
Benzene	560	14	<0.38	<0.39	<0.42	<0.38	<0.35	<0.35	<0.33	<0.4	<0.38	<0.38
Ethylbenzene	29000	160	<0.38	<0.39	<0.42	<0.38	<0.35	<0.35	<0.33	<0.4	<0.38	<0.38
Toluene	49000	310	<0.38	<0.39	0.64	<0.38	<0.35	0.41	<0.33	<0.4	<0.38	<0.38
Xylenes, Total	4800	170	<0.38	<0.39	<0.42	<0.38	<0.35	<0.35	<0.33	<0.4	<0.38	<0.38
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	<0.4	<0.41	<0.45	<0.41	<0.37	<0.38	<0.35	1.6	<0.4	<0.41
Acenaphthylene	5900	2800	<0.4	1.9	<0.45	<0.41	<0.37	<0.38	<0.35	4.5	5.1	1
Anthracene	250000	6000	<0.4	1.4	<0.45	<0.41	0.76	1	<0.35	<17	3.3	2
Benzo(a)anthracene	790	5.1	<0.4	[12]	0.63	<0.41	1.7	2.7	0.38	[54]	[16]	[6.4]
Benzo(a)pyrene	79	0.51	<0.4	[3.9]	<0.45	<0.41	[0.8]	[1.1]	<0.35	[25]	[10]	[4.1]
Benzo(b)fluoranthene	790	5.1	<0.4	1.4	0.59	0.41	0.76	1.4	<0.35	[27]	[10]	4
Benzo(g,h,i)perylene	NA	NA	<0.4	<0.41	0.88	<0.41	0.67	0.89	<0.35	19	11	3
Benzo(k)fluoranthene	7900	51	<0.4	<0.41	<0.45	<0.41	0.49	0.48	<0.35	<17	2.9	1.5
Chrysene	79000	510	<0.4	20	0.99	<0.41	2	3.3	0.59	44	23	8.4
Dibenz(a,h)anthracene	79	0.51	<0.4	[1.2]	<0.45	<0.41	<0.37	<0.38		[3.9]	[1.5]	[0.73]
Fluoranthene	33000	6000	0.52	39	1.1	<0.41	3.6	0.4	0.82	68	26	8.9
Fluorene	33000	6000	<0.4	<0.41	<0.45	<0.41	<0.37	<0.38	<0.35	2.3	0.91	0.46
Indeno(1,2,3-cd)pyrene	790	5.1	<0.4	<0.41	0.67	<0.41	0.68	0.9	<0.35	[19]	[<8]	2.8
Naphthalene	17000	6000	<0.4	<0.41	<0.45	<0.41	<0.37	<0.38	<0.35	3.5	0.48	0.57
Phenanthrene	2500	1200	<0.4	6	<0.45	<0.41	2	2.2	<0.35	28	13	4.7
Pyrene	25000	6000	0.52	52	1.3	0.49	4.6	4	0.91	71	56	8.4
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	10000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	450	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	650	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	260	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	4300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	<0.16	4.8	<0.18	0.17	<0.28	<0.28	<0.27	3.2	5	<0.31
Cyanide, WAD	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site			SS-10	SS-11	SS-12	TS-SB-01	TS-SB-02	TS-SB-02	TS-SB-03	TS-SB-04	TS-SB-05	TS-SB-06
Sample ID			SS-10	SS-11	SS-12	TS-SB-1(17-18')	TS-SB-2(16-18')	TS-SB-2(16-18')FD	TS-SB-3(17-18.5')	TS-SB-4(1-3')	TS-SB-5(20-21')	TS-SB-6(16-18')
Date			4/3/1996	4/3/1996	4/3/1996	5/4/2011	5/4/2011	5/4/2011	5/4/2011	5/4/2011	5/4/2011	5/4/2011
Depth (ft)			2	1.5	1.5	18	18	18	18.5	3	21	18
CONSTITUENT	CWDC	RNCL	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary
BTEX (mg/Kg)												
Benzene	560	14	0.37	<0.36	<0.38	[72]	1.6	7.9	<0.5	<0.0045	2.1	<0.0052
Ethylbenzene	29000	160	<0.37	<0.36	<0.38	[160]	13	[160]	1.5	<0.0045	20	<0.0052
Toluene	49000	310	<0.37	0.75	<0.38	22	<0.84	11	0.88	<0.0045	<0.52	<0.0052
Xylenes, Total	4800	170	<0.37	1.3	<0.38	[180]	7.9	[180]	3.3	<0.009	8.4	0.04
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	3.2	<0.38	<0.41	8.9	19	36	1.2	<0.36	36	<0.37
Acenaphthylene	5900	2800	3.1	<0.38	<0.41	0.51	<4.4	<4.9	<0.42	<0.36	<3.8	<0.37
Anthracene	250000	6000	<19	<0.38	<0.41	3.3	23	40	2.1	<0.36	17	<0.37
Benzo(a)anthracene	790	5.1	[44]	<0.38	0.96	2.1	[23]	[46]	0.66	<0.36	[10]	<0.37
Benzo(a)pyrene	79	0.51	[<19]	<0.38	[1.4]	[1.7]	[19]	[42]	[0.57]	<0.36	[10]	<0.37
Benzo(b)fluoranthene	790	5.1	[<19]	<0.38	1.2	0.74	[15]	[33]	<0.42	<0.36	[5.4]	<0.37
Benzo(g,h,i)perylene	NA	NA	6.3	<0.38	0.72	0.59	7.4	22	<0.42	<0.36	5	<0.37
Benzo(k)fluoranthene	7900	51	3.7	<0.38	0.42	0.88	15	37	0.45	<0.36	6.5	<0.37
Chrysene	79000	510	44	<0.38	1	2.2	25	55	0.59	<0.36	10	<0.37
Dibenz(a,h)anthracene	79	0.51	[2.3]	<0.38	<0.41	<0.4	[<4.4]	[8.8]	<0.42	<0.36	[<3.8]	<0.37
Fluoranthene	33000	6000	59	<0.38	1.8	3.5	47	140	1.5	<0.36	24	<0.37
Fluorene	33000	6000	4.2	<0.38	<0.41	4.8	28	66	3.3	<0.36	15	<0.37
Indeno(1,2,3-cd)pyrene	790	5.1	[<19]	<0.38	0.56	0.46	[7.1]	[21]	<0.42	<0.36	<3.8	<0.37
Naphthalene	17000	6000	3.1	<0.38	<0.41	44	46	160	14	<0.36	170	<0.37
Phenanthrene	2500	1200	41	<0.38	1.1	18	86	210	3.4	<0.36	80	<0.37
Pyrene	25000	6000	80	<0.38	2.6	6.6	48	100	1.8	<0.36	36	<0.37
Metals (mg/Kg)												
Arsenic	320	13	NA	NA	NA	6.1	8.8	[15]	5.2	4.9	4.4	4.6
Barium	220000	10000	NA	NA	NA	57	110	97	66	22	44	40
Cadmium	590	450	NA	NA	NA	<0.61	<0.64	0.96	<0.59	<0.51	<0.56	<0.51
Chromium	3400	650	NA	NA	NA	16	9.4	9.8	19	6.3	12	9.2
Lead	970	400	NA	NA	NA	9.4	[580]	[1500]	11	5	6.8	5.7
Mercury	340	260	NA	NA	NA	<0.015	0.12	4.3	0.054	<0.022	0.018	<0.016
Selenium	5700	4300	NA	NA	NA	<1.2	<1.3	<1.4	<1.2	<1	<1.1	<1
Silver	5700	4300	NA	NA	NA	<1.2	<1.3	<1.4	<1.2	<1	<1.1	<1
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	1.4	<0.29	0.95	NA	NA	NA	NA	NA	NA	NA
Cyanide, WAD	23000	6000	NA	NA	NA	<0.16	<0.17	0.27	0.21	<0.14	<0.15	<0.15

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site **Sample ID** **Date** **Depth (ft)** **CONSTITUENT**	**CWDC**	**RNCL**	**TS-SS-01** **TS-SS-1(0.0-0.5')** **5/4/2011** **0.5** **Primary**	**TS-SS-01** **TS-SS-1(0.5-1')** **5/4/2011** **1** **Primary**	**TS-SS-02** **TS-SS-2(0-0.5')** **5/9/2011** **0.5** **Primary**	**TS-SS-02** **TS-SS-2-FD(0-0.5')** **5/9/2011** **0.5** **Duplicate 1**	**TS-SS-02** **TS-SS-2(0.5-1')** **5/9/2011** **0.5** **Primary**	**TS-SS-03** **TS-SS-3(0.0-0.5')** **5/4/2011** **0.5** **Primary**	**TS-SS-03** **TS-SS-3(0.5-1')** **5/4/2011** **1** **Primary**	**TS-SS-03** **TS-SS-3(0.5-1')FD** **5/4/2011** **1** **Duplicate 1**	**TS-SS-04** **TS-SS-4(0-0.5')** **5/9/2011** **0.5** **Primary**	**TS-SS-04** **TS-SS-4(0.5-1')** **5/9/2011** **0.5** **Primary**
BTEX (mg/Kg)												
Benzene	560	14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	29000	160	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	49000	310	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes, Total	4800	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	<0.42	<0.39	<0.74	<0.36	<0.73	<0.71	<0.78	<0.74	<0.4	<0.37
Acenaphthylene	5900	2800	<0.42	<0.39	<0.74	<0.36	<0.73	<0.71	<0.78	<0.74	<0.4	<0.37
Anthracene	250000	6000	<0.42	<0.39	<0.74	0.62	<0.73	<0.71	<0.78	<0.74	<0.4	0.52
Benzo(a)anthracene	790	5.1	<0.42	<0.39	<0.74	1	<0.73	<0.71	<0.78	0.75	<0.4	1.1
Benzo(a)pyrene	79	0.51	0.48	<0.39	[<0.74]	**[1.1]**	**[1]**	[<0.71]	[<0.78]	**[0.94]**	<0.4	**[1.2]**
Benzo(b)fluoranthene	790	5.1	<0.42	<0.39	<0.74	0.58	<0.73	<0.71	<0.78	0.84	<0.4	0.85
Benzo(g,h,i)perylene	NA	NA	<0.42	<0.39	<0.74	1.1	1.1	<0.71	1.2	1.7	<0.4	1.3
Benzo(k)fluoranthene	7900	51	<0.42	<0.39	<0.74	0.78	<0.73	<0.71	<0.78	0.76	<0.4	0.92
Chrysene	79000	510	0.52	<0.39	<0.74	1.2	0.91	<0.71	0.96	1.1	<0.4	1.4
Dibenz(a,h)anthracene	79	0.51	<0.42	<0.39	[<0.74]	0.45	[<0.73]	[<0.71]	[<0.78]	[<0.74]	<0.4	**[0.55]**
Fluoranthene	33000	6000	0.77	<0.39	<0.74	2.2	1	<0.71	<0.78	<0.74	<0.4	2.4
Fluorene	33000	6000	<0.42	<0.39	<0.74	<0.36	<0.73	<0.71	<0.78	<0.74	<0.4	<0.37
Indeno(1,2,3-cd)pyrene	790	5.1	<0.42	<0.39	<0.74	0.9	0.92	<0.71	0.92	1.3	<0.4	1.1
Naphthalene	17000	6000	<0.42	<0.39	<0.74	<0.36	<0.73	<0.71	<0.78	<0.74	<0.4	<0.37
Phenanthrene	2500	1200	0.47	<0.39	<0.74	1.9	<0.73	<0.71	<0.78	<0.74	<0.4	1.8
Pyrene	25000	6000	0.94	<0.39	1	2.9	1.3	<0.71	1.5	1.2	<0.4	2.2
Metals (mg/Kg)												
Arsenic	320	13	**[15]**	**[14]**	7.7	7.3	5.3	6	7	8.7	12	9
Barium	220000	10000	110	110	51	46	49	30	77	61	98	54
Cadmium	590	450	0.94	<0.54	<0.56	0.86	0.56	<0.49	<0.59	<0.52	0.56	<0.55
Chromium	3400	650	19	24	11	9.5	12	5.8	5.9	9	22	11
Lead	970	400	160	32	79	55	64	44	19	61	28	98
Mercury	340	260	0.23	0.094	0.038	0.049	0.029	0.15	0.11	0.34	0.059	0.055
Selenium	5700	4300	<1.2	<1.1	<1.1	<1	<1	<0.98	<1.2	<1	<4.4	<1.1
Silver	5700	4300	<1.2	<1.1	<1.1	<1	<1	<0.98	<1.2	<1	<1.1	<1.1
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide, WAD	23000	6000	<0.16	<0.15	<0.14	<0.14	<0.14	<0.14	<0.15	<0.14	<0.16	<0.14

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	TS-SS-05 TS-SS-5(0-0.5') 5/9/2011 0.5 Primary	TS-SS-05 TS-SS-5(0.5-1') 5/9/2011 0.5 Primary	TS-SS-06 TS-SS-6(0.0-0.5') 5/4/2011 0.5 Primary	TS-SS-06 TS-SS-6(0.5-1') 5/4/2011 1 Primary	TS-SS-07 TS-SS-7(0-0.5') 5/9/2011 0.5 Primary	TS-SS-07 TS-SS-7(0.5-1') 5/9/2011 0.5 Primary	TS-SS-08 TS-SS-8(0-0.5') 5/9/2011 0.5 Primary	TS-SS-08 TS-SS-8(0.5-1') 5/9/2011 0.5 Primary	TS-SS-09 TS-SS-9(0-0.5') 5/9/2011 0.5 Primary	TS-SS-09 TS-SS-9(0.5-1') 5/9/2011 0.5 Primary
BTEX (mg/Kg)												
Benzene	560	14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	29000	160	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	49000	310	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes, Total	4800	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs (mg/Kg)												
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	<0.37	<0.38	<0.38	<0.4	<0.39	<0.36	<0.36	<0.38	<0.39	37
Acenaphthylene	5900	2800	<0.37	<0.38	<0.38	<0.4	<0.39	<0.36	<0.36	<0.38	<0.39	67
Anthracene	250000	6000	<0.37	<0.38	<0.38	<0.4	<0.39	<0.36	<0.36	<0.38	<0.39	85
Benzo(a)anthracene	790	5.1	1	0.6	1.3	2.8	<0.39	<0.36	<0.36	1.3	<0.39	**[60]**
Benzo(a)pyrene	79	0.51	**[1.4]**	**[0.66]**	**[1.3]**	**[2.8]**	<0.39	<0.36	<0.36	**[1.5]**	<0.39	**[43]**
Benzo(b)fluoranthene	790	5.1	0.91	0.42	0.92	1.8	<0.39	<0.36	<0.36	1.1	<0.39	**[30]**
Benzo(g,h,i)perylene	NA	NA	1.4	0.57	1.3	2	<0.39	<0.36	<0.36	0.84	<0.39	18
Benzo(k)fluoranthene	7900	51	0.96	0.48	0.9	2	<0.39	<0.36	<0.36	1.2	<0.39	35
Chrysene	79000	510	1.4	0.74	1.4	3	0.43	<0.36	<0.36	1.4	<0.39	60
Dibenz(a,h)anthracene	79	0.51	0.49	<0.38	**[0.59]**	**[1.1]**	<0.39	<0.36	<0.36	0.43	<0.39	**[13]**
Fluoranthene	33000	6000	2.2	1.4	1.3	2.9	1.1	<0.36	0.38	1.6	<0.39	110
Fluorene	33000	6000	<0.37	<0.38	<0.38	<0.4	<0.39	<0.36	<0.36	<0.38	<0.39	130
Indeno(1,2,3-cd)pyrene	790	5.1	1	0.51	1.1	1.9	<0.39	<0.36	<0.36	0.76	<0.39	**[18]**
Naphthalene	17000	6000	<0.37	<0.38	<0.38	<0.4	<0.39	<0.36	<0.36	<0.38	<0.39	140
Phenanthrene	2500	1200	1.1	1.3	0.5	0.72	1.2	<0.36	<0.36	0.58	<0.39	230
Pyrene	25000	6000	2.2	1.3	1.9	3.6	0.87	<0.36	0.42	2.3	0.49	110
Metals (mg/Kg)												
Arsenic	320	13	**[14]**	9.6	7.4	8.6	12	7.9	7.1	7.9	3.9	2.9
Barium	220000	10000	54	57	38	74	98	33	47	59	55	100
Cadmium	590	450	<0.55	<0.57	<0.53	<0.56	<0.6	<0.53	<0.51	<0.58	<0.58	<0.56
Chromium	3400	650	11	14	8.8	12	20	7.9	13	14	9.4	5.8
Lead	970	400	120	48	87	73	24	9.7	18	51	8.6	8.6
Mercury	340	260	0.074	0.065	0.6	8.4	0.056	<0.019	0.03	0.18	0.024	0.1
Selenium	5700	4300	<2.2	<2.2	<1.1	<1.1	<3.6	<1	<2	<1.2	<1.2	<1.1
Silver	5700	4300	<1.1	<1.1	<1.1	<1.1	<1.2	<1	<1	<1.2	<1.2	<1.1
Cyanide (mg/Kg)												
Cyanide, Total**	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide, WAD	23000	6000	<0.15	0.21	<0.15	0.2	<0.16	<0.14	<0.14	<0.15	0.17	<0.16

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Site			TS-SS-10	TS-SS-10	TS-SS-11	TS-SS-11	TS-SS-12	TS-SS-12	TS-SS-13	TS-SS-13	TS-SS-13
Sample ID			TS-SS-10(0.0-0.5')	TS-SS-10(0.5-1')	TS-SS-11(0-0.5')	TS-SS-11(0.5-1')	TS-SS-12(0.0-0.5')	TS-SS-12(0.5-1')	TS-SS-13(0-0.5')	TS-SS-13-FD(0-0.5')	TS-SS-13(0.5-1')
Date			5/4/2011	5/4/2011	5/9/2011	5/9/2011	5/4/2011	5/4/2011	5/9/2011	5/9/2011	5/9/2011
Depth (ft)			0.5	1	0.5	0.5	0.5	1	0.5	0.5	0.5
CONSTITUENT	CWDC	RNCL	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary
BTEX (mg/Kg)											
Benzene	560	14	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	29000	160	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	49000	310	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes, Total	4800	170	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs (mg/Kg)											
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	6000	<0.37	<0.38	<3.7	<0.37	<0.8	<0.41	<0.76	<0.39	<0.38
Acenaphthylene	5900	2800	<0.37	<0.38	<3.7	<0.37	<0.8	<0.41	<0.76	<0.39	<0.38
Anthracene	250000	6000	<0.37	<0.38	<3.7	<0.37	<0.8	<0.41	<0.76	<0.39	<0.38
Benzo(a)anthracene	790	5.1	0.8	<0.38	<3.7	<0.37	1.1	0.66	<0.76	0.39	<0.38
Benzo(a)pyrene	79	0.51	**[0.91]**	**[0.52]**	[<3.7]	<0.37	**[1.2]**	**[1.1]**	[<0.76]	0.5	<0.38
Benzo(b)fluoranthene	790	5.1	0.58	<0.38	<3.7	<0.37	0.91	0.68	<0.76	0.57	0.39
Benzo(g,h,i)perylene	NA	NA	0.88	<0.38	<3.7	<0.37	1.6	1.5	0.96	0.76	0.44
Benzo(k)fluoranthene	7900	51	0.53	<0.38	<3.7	<0.37	0.82	0.83	<0.76	0.51	<0.38
Chrysene	79000	510	0.93	<0.38	<3.7	<0.37	1.4	0.87	<0.76	0.56	0.39
Dibenz(a,h)anthracene	79	0.51	0.44	<0.38	[<3.7]	<0.37	[<0.8]	**[0.58]**	[<0.76]	<0.39	<0.38
Fluoranthene	33000	6000	1.4	<0.38	<3.7	0.47	2.3	0.69	<0.76	0.54	<0.38
Fluorene	33000	6000	<0.37	<0.38	<3.7	<0.37	<0.8	<0.41	<0.76	<0.39	<0.38
Indeno(1,2,3-cd)pyrene	790	5.1	0.74	<0.38	<3.7	<0.37	1.2	1.1	<0.76	0.54	<0.38
Naphthalene	17000	6000	<0.37	<0.38	<3.7	<0.37	<0.8	<0.41	<0.76	<0.39	<0.38
Phenanthrene	2500	1200	0.98	<0.38	<3.7	<0.37	1.9	<0.41	<0.76	<0.39	<0.38
Pyrene	25000	6000	1.6	0.73	4	0.61	2.1	0.84	1.3	0.96	0.61
Metals (mg/Kg)											
Arsenic	320	13	8.2	3.5	11	9.2	10	**[21]**	**[14]**	**[18]**	**[17]**
Barium	220000	10000	39	43	33	64	80	140	110	110	210
Cadmium	590	450	<0.51	<0.52	0.73	<0.5	0.67	<0.59	1	1.1	0.77
Chromium	3400	650	11	17	7.9	11	9.7	9.2	16	18	20
Lead	970	400	32	8.2	50	22	110	180	95	79	47
Mercury	340	260	0.03	<0.023	0.067	0.031	0.1	0.12	0.086	0.067	0.069
Selenium	5700	4300	1.2	<1.1	<1.1	<2	<1.1	<1.2	<1.1	<1.1	<1.1
Silver	5700	4300	<1	<1.1	<1.1	<1	<1.1	<1.2	<1.1	<1.1	<1.1
Cyanide (mg/Kg)											
Cyanide, Total**	23000	6000	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide, WAD	23000	6000	<0.15	<0.15	<0.15	<0.14	<0.16	<0.16	<0.15	<0.16	<0.15

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

Table 7
Historical Surface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	RNCL	TS-SS-14 TS-SS-14(0-0.5') 5/9/2011 0.5 Primary	TS-SS-14 TS-SS-14(0.5-1') 5/9/2011 0.5 Primary	TS-SS-15 TS-SS-15(0-0.5') 5/9/2011 0.5 Primary	TS-SS-15 TS-SS-15(0.5-1') 5/9/2011 0.5 Primary
BTEX (mg/Kg)						
Benzene	560	14	NA	NA	NA	NA
Ethylbenzene	29000	160	NA	NA	NA	NA
Toluene	49000	310	NA	NA	NA	NA
Xylenes, Total	4800	170	NA	NA	NA	NA
PAHs (mg/Kg)						
2-Methylnaphthalene	3300	1600	NA	NA	NA	NA
Acenaphthene	50000	6000	<0.42	<0.41	<2.1	<1.9
Acenaphthylene	5900	2800	<0.42	<0.41	<2.1	<1.9
Anthracene	250000	6000	<0.42	<0.41	<2.1	<1.9
Benzo(a)anthracene	790	5.1	<0.42	<0.41	[16]	[22]
Benzo(a)pyrene	79	0.51	<0.42	<0.41	[17]	[22]
Benzo(b)fluoranthene	790	5.1	<0.42	<0.41	[21]	[25]
Benzo(g,h,i)perylene	NA	NA	<0.42	<0.41	31	35
Benzo(k)fluoranthene	7900	51	<0.42	<0.41	19	28
Chrysene	79000	510	<0.42	<0.41	23	27
Dibenz(a,h)anthracene	79	0.51	<0.42	<0.41	[7.7]	[12]
Fluoranthene	33000	6000	<0.42	<0.41	23	29
Fluorene	33000	6000	<0.42	<0.41	<2.1	<1.9
Indeno(1,2,3-cd)pyrene	790	5.1	<0.42	<0.41	[21]	[25]
Naphthalene	17000	6000	<0.42	<0.41	<2.1	<1.9
Phenanthrene	2500	1200	<0.42	<0.41	2.7	4
Pyrene	25000	6000	<0.42	<0.41	52	62
Metals (mg/Kg)						
Arsenic	320	13	[14]	12	[28]	[26]
Barium	220000	10000	96	95	180	200
Cadmium	590	450	0.77	0.61	2.2	2.5
Chromium	3400	650	19	19	21	18
Lead	970	400	58	46	260	[600]
Mercury	340	260	0.078	0.32	0.49	0.082
Selenium	5700	4300	<2.3	<3.5	<5.2	<1.1
Silver	5700	4300	<1.2	<1.2	<1.3	<1.1
Cyanide (mg/Kg)						
Cyanide, Total**	23000	6000	NA	NA	NA	NA
Cyanide, WAD	23000	6000	<0.17	<0.16	1.4	0.86

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[21]	Reported above RNCL
[21]	Reported above RNCL and CWDC
[<84]	Laboratory reporting limit above action level

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Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site				BNTP-04	BNTP-04S	BNTP-05	MW-001	MW-001	MW-001	MW-002	MW-002	MW-003	MW-003
Sample ID				BNTP-4	BNTP-4S	BNTP-5	SB/MW-1	SB/MW-1	SB/MW-1	SB/MW-2	SB/MW-2	SB/MW-3	SB/MW-3
Date				1/29/2007	1/29/2007	1/29/2007	10/1/1994	10/1/1994	10/1/1994	10/1/1994	10/1/1994	10/1/1994	10/1/1994
Depth (ft)				0	0	0	14	22	22	4	14	10	16
CONSTITUENT	**CWDC**	**I-MTGW**	**R-MTGW**	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	<0.0056	<0.0063	<0.0063	[<1.4]	[<0.39]	[<0.36]	[<0.34]	**[2.3]**	**[0.39]**	[<1.6]
Ethylbenzene	29000	200	13	<0.0056	<0.0063	<0.0063	**[20]**	2.5	2.6	<0.34	3.4	<0.39	10
Toluene	49000	96	12	<0.0056	<0.0063	<0.0063	<1.4	<0.39	<0.36	<0.34	3.4	0.55	3.2
Xylene (total)	4800	430	210	<0.0056	<0.0063	<0.0063	16	2.2	2.1	<0.34	5.9	<0.39	17
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	1800	130	0.0687	<0.062	<0.064	110	25	**[140]**	<3.7	20	<0.82	45
Acenaphthylene	5900	180	18	0.497	0.12	0.0903	[<39]	<4.2	[<39]	<3.7	[<19]	<0.82	<17
Anthracene	250000	36000	2700	0.589	0.062	<0.064	45	10	50	<3.7	<19	<0.82	47
Benzo(a)anthracene	790	62	19	1.66	0.124	0.177	[<39]	7.1	[<39]	<3.7	[<19]	3.2	**[41]**
Benzo(a)pyrene	79	16	8.2	1.43	0.142	0.248	[<39]	6.7	[<39]	<3.7	[<19]	2.9	**[29]**
Benzo(b)fluoranthene	790	190	57	1.03	0.0948	0.192	<39	5.1	<39	<3.7	<19	3.8	30
Benzo(g,h,i)perylene	NA	NA	NA	0.697	0.0802	0.184	<39	4.3	<39	<3.7	<19	2	<17
Benzo(k)fluoranthene	7900	1900	570	1.07	0.0985	0.2	<39	<4.2	<39	<3.7	<19	1.1	<17
Chrysene	79000	6200	1900	1.66	0.128	0.192	<39	6.2	<39	<3.7	<19	2.6	32
Dibenz(a,h)anthracene	79	60	18	0.291	<0.062	<0.064	[<39]	<4.2	[<39]	<3.7	[<19]	<0.82	<17
Fluoranthene	33000	18000	6300	2.37	0.182	0.211	66	16	65	<3.7	30	4.2	83
Fluorene	33000	2300	170	0.298	<0.062	<0.064	45	12	52	<3.7	32	<0.82	59
Indeno(1,2,3-cd)pyrene	790	540	160	0.599	0.0657	0.154	<39	<4.2	<39	<3.7	<19	1.8	<17
Naphthalene	17000	170	0.7	0.137	0.0657	<0.064	**[190]**	**[47]**	**[260]**	[<3.7]	**[210]**	[<0.82]	**[220]**
Phenanthrene	2500	170	13	2.24	0.153	0.113	**[180]**	**[47]**	**[210]**	<3.7	**[120]**	<0.82	**[180]**
Pyrene	25000	13000	4600	2.89	0.193	0.23	140	<4.2	130	<3.7	51	4.1	100
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	17000	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	77	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	120	38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	230	81	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	32	2.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	53	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	87	31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	**[77.9]**	<0.157	**[3.63]**	<0.74	**[6.2]**	**[0.96]**	<0.28	<0.29	0.59	**[18]**
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[41]	Reported above R-MTGW
[35]	Reported above I-MTGW and R-MTGW
[84]	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site				**MW-004**	**MW-004**	**MW-004**	**MW-005**	**MW-005**	**MW-006**	**MW-006**	**MW-007**	**MW-101**	**MW-101**
Sample ID				**SB/MW-4 (14-16)**	**SB/MW-4 (20-22)**	**SB/MW-4 (20-22)**	**MW-5**	**MW-5**	**MW-6**	**MW-6**	**MW-7**	**SB/MW-101**	**SB/MW-101**
Date				**10/20/1994**	**10/20/1994**	**10/20/1994**	**1/29/2007**	**1/29/2007**	**1/29/2007**	**1/29/2007**	**1/29/2007**	**10/9/1995**	**10/9/1995**
Depth (ft)				**16**	**22**	**22**	**2**	**12**	**2**	**10**	**2**	**10**	**10**
CONSTITUENT	**CWDC**	**I-MTGW**	**R-MTGW**	**Primary**	**Primary**	**Duplicate 1**	**Primary**	**Primary**	**Primary**	**Primary**	**Primary**	**Primary**	**Duplicate 1**
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	[<0.35]	[<3.9]	[<0.34]	<0.0062	0.031	<0.0062	**[19.8]**	<0.0053	[<0.36]	[<0.36]
Ethylbenzene	29000	200	13	<0.35	12	<0.34	<0.0062	1.06	<0.0062	**[119]**	<0.0053	<0.36	<0.36
Toluene	49000	96	12	<0.35	<3.9	<0.34	<0.0062	<0.0131	<0.0062	6.95	<0.0053	<0.36	<0.36
Xylene (total)	4800	430	210	<0.35	11	<0.34	<0.0062	0.201	<0.0062	109	<0.0053	<0.36	<0.36
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	[<24]	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	1800	130	<3.8	56	<3.6	0.177	1.96	<0.0635	90	<0.0533	<0.39	<0.38
Acenaphthylene	5900	180	18	<3.8	**[26]**	<3.6	0.331	0.0932	1.37	**[18.9]**	<0.0533	<0.39	<0.38
Anthracene	250000	36000	2700	<3.8	48	7	0.177	0.974	0.385	81.8	<0.0533	<0.39	<0.38
Benzo(a)anthracene	790	62	19	<3.8	**[38]**	10	0.421	0.519	1.3	**[62.8]**	0.0784	<0.39	<0.38
Benzo(a)pyrene	79	16	8.2	<3.8	**[29]**	6.5	0.41	0.482	0.467	**[71.6]**	0.0659	<0.39	<0.38
Benzo(b)fluoranthene	790	190	57	<3.8	26	8.2	0.448	0.201	1.22	30.7	0.0533	<0.39	<0.38
Benzo(g,h,i)perylene	NA	NA	NA	<3.8	<24	<3.6	0.482	0.202	1.38	38.7	<0.0533	<0.39	<0.38
Benzo(k)fluoranthene	7900	1900	570	<3.8	<24	<3.6	0.467	0.294	1.42	45	0.0565	<0.39	<0.38
Chrysene	79000	6200	1900	<3.8	29	7.7	0.493	0.479	1.65	61.2	0.0565	<0.39	<0.38
Dibenz(a,h)anthracene	79	60	18	<3.8	[<24]	<3.6	0.102	0.0595	0.321	10.3	<0.0533	<0.39	<0.38
Fluoranthene	33000	18000	6300	<3.8	77	20	0.719	1.22	1.91	167	0.122	<0.39	<0.38
Fluorene	33000	2300	170	<3.8	51	4.1	0.132	0.97	0.183	62.6	<0.0533	<0.39	<0.38
Indeno(1,2,3-cd)pyrene	790	540	160	<3.8	<24	<3.6	0.35	0.157	1.04	27.7	<0.0533	<0.39	<0.38
Naphthalene	17000	170	0.7	[<3.8]	**[320]**	[<3.6]	0.241	0.161	0.306	**[488]**	<0.0533	<0.39	<0.38
Phenanthrene	2500	170	13	<3.8	**[180]**	**[27]**	0.5	0.399	0.815	**[269]**	0.0627	<0.39	<0.38
Pyrene	25000	13000	4600	<3.8	99	15	0.88	1.72	3.04	210	0.107	<0.39	<0.38
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	**[9.72]**	NA	**[7.69]**	NA	**[22.1]**	NA	NA
Barium	220000	17000	1600	NA	NA	NA	70.1	NA	51.7	NA	109	NA	NA
Cadmium	590	77	7.5	NA	NA	NA	<6.06	NA	<6.43	NA	<5.35	NA	NA
Chromium	3400	120	38	NA	NA	NA	14.2	NA	8.98	NA	12.2	NA	NA
Lead	970	230	81	NA	NA	NA	44.9	NA	32.1	NA	42.2	NA	NA
Mercury	340	32	2.1	NA	NA	NA	0.0505	NA	0.0746	NA	0.0617	NA	NA
Selenium	5700	53	5.2	NA	NA	NA	[<20.2]	NA	[<21.4]	NA	[<17.8]	NA	NA
Silver	5700	87	31	NA	NA	NA	<0.63	NA	<0.636	NA	<0.508	NA	NA
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	<0.15	0.44	<0.27	**[12.4]**	0.241	**[73.2]**	**[92]**	<0.134	<0.15	<0.15
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared to Free Cyanide action level

[41] (green)	Reported above R-MTGW
[35] (blue)	Reported above I-MTGW and R-MTGW
[84] (red)	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

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Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site				MW-101	MW-101	MW-102	MW-102	MW-102	SB-005	SB-007	SB-007	SB-009	SB-009
Sample ID				SB/MW-101	SB/MW-101	SB/MW-102	SB/MW-102	SB/MW-102	SB-5 (6-8)	SB-7	SB-7	SB-9 (2-4)	SB-9 (4-6)
Date				10/9/1995	10/9/1995	10/10/1995	10/10/1995	10/10/1995	10/21/1994	10/1/1994	10/1/1994	10/20/1994	10/20/1994
Depth (ft)				18	20	10	20	20	8	10	14	4	6
CONSTITUENT	CWDC	I-MTGW	R-MTGW	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	[<0.34]	NA	[<0.36]	[<0.34]	NA	[<0.33]	**[1.2]**	[<0.39]	[<0.35]	[<0.37]
Ethylbenzene	29000	200	13	<0.34	NA	<0.36	<0.34	NA	<0.33	4.8	**[18]**	<0.35	<0.37
Toluene	49000	96	12	<0.34	NA	<0.36	<0.34	NA	<0.33	3.1	<0.39	<0.35	<0.37
Xylene (total)	4800	430	210	<0.34	NA	<0.36	<0.34	NA	<0.33	4.4	4.2	<0.35	<0.37
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	NA	NA	NA	NA	<0.35	NA	NA	**[4.1]**	**[3.7]**
Acenaphthene	50000	1800	130	19	NA	<0.38	<0.36	NA	<0.35	<4.1	92	6.9	6.2
Acenaphthylene	5900	180	18	2.6	NA	<0.38	<0.36	NA	<0.35	4.1	[<20]	9.2	7.8
Anthracene	250000	36000	2700	10	NA	0.45	<0.36	NA	<0.35	<4.1	61	14	12
Benzo(a)anthracene	790	62	19	7	NA	1.9	<0.36	NA	<0.35	4.6	**[35]**	14	11
Benzo(a)pyrene	79	16	8.2	5	NA	2.2	<0.36	NA	<0.35	**[8.4]**	**[49]**	7	6.5
Benzo(b)fluoranthene	790	190	57	3.6	NA	2	<0.36	NA	<0.35	10	39	8.5	8
Benzo(g,h,i)perylene	NA	NA	NA	2.4	NA	1.3	<0.36	NA	<0.35	16	29	3.8	3.8
Benzo(k)fluoranthene	7900	1900	570	<1.8	NA	0.69	<0.36	NA	<0.35	<4.1	<20	3.1	<3.1
Chrysene	79000	6200	1900	6	NA	1.5	<0.36	NA	<0.35	<4.1	32	10	8.6
Dibenz(a,h)anthracene	79	60	18	<1.8	NA	<0.38	<0.36	NA	<0.35	<4.1	[<20]	<3	<3.1
Fluoranthene	33000	18000	6300	10	NA	2.3	<0.36	NA	<0.35	10	100	22	19
Fluorene	33000	2300	170	13	NA	<0.38	<0.36	NA	<0.35	<4.1	46	19	17
Indeno(1,2,3-cd)pyrene	790	540	160	<1.8	NA	0.77	<0.36	NA	<0.35	11	31	3.5	3.4
Naphthalene	17000	170	0.7	[<1.8]	NA	<0.38	<0.36	NA	<0.35	[<4.1]	**[140]**	**[4.8]**	**[4.4]**
Phenanthrene	2500	170	13	**[25]**	NA	2.2	<0.36	NA	<0.35	7	**[210]**	**[44]**	**[39]**
Pyrene	25000	13000	4600	22	NA	5.5	0.54	NA	<0.35	6	96	20	19
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	17000	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	77	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	120	38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	230	81	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	32	2.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	53	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	87	31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	<0.55	<0.15	<0.58	<0.14	<0.57	<0.14	**[46]**	**[14]**	<0.15	<0.15
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared to Free Cyanide action level

[41]	Reported above R-MTGW
[35]	Reported above I-MTGW and R-MTGW
[84]	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

AECOM

Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	I-MTGW	R-MTGW	SB-010 SB-10 10/1/1994 10 Primary	SB-010 SB-10 10/1/1994 16 Primary	SB-013 SB-13 10/1/1994 22 Primary	SB-014 SB-14 (6-8) 10/21/1994 8 Primary	SB-014 SB-14 (14-16) 10/21/1994 16 Primary	SB-016 SB-16 (6-8) 10/24/1994 8 Primary	SB-016 SB-16 (6-8) 10/24/1994 8 Duplicate 1	SB-016 SB-16 (12-14) 10/24/1994 12 Primary	SB-017 SB-17 (2-4) 10/18/1994 4 Primary	SB-017 SB-17 (4-6) 10/18/1994 6 Primary
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	**[0.63]**	**[11]**	**[14]**	[<0.39]	[<0.39]	[<0.34]	[<0.35]	**[0.35]**	[<0.36]	[<0.36]
Ethylbenzene	29000	200	13	0.72	<3.4	<4.5	<0.39	<0.39	<0.34	<0.35	<0.35	<0.36	<0.36
Toluene	49000	96	12	1.7	**[12]**	**[26]**	<0.39	<0.39	<0.34	<0.35	<0.35	<0.36	<0.36
Xylene (total)	4800	430	210	4.5	16	38	<0.39	<0.39	<0.34	<0.35	<0.35	<0.36	<0.36
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	NA	NA	NA	NA	NA	NA	**[5.2]**	NA	NA
Acenaphthene	50000	1800	130	<3.8	<18	<96	<42	4.8	<0.36	<0.38	<0.72	<0.39	<0.38
Acenaphthylene	5900	180	18	<3.8	**[22]**	**[220]**	[<42]	4.4	<0.36	<0.38	<0.72	<0.39	<0.38
Anthracene	250000	36000	2700	4	<18	230	<42	15	<0.36	<0.38	1.2	<0.39	<0.38
Benzo(a)anthracene	790	62	19	4.2	<18	**[120]**	**[710]**	12	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(a)pyrene	79	16	8.2	<3.8	[<18]	[<96]	**[460]**	**[11]**	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(b)fluoranthene	790	190	57	<3.8	<18	[<96]	**[700]**	14	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(g,h,i)perylene	NA	NA	NA	<3.8	<18	<96	560	15	<0.36	<0.38	<0.72	<0.39	<0.38
Benzo(k)fluoranthene	7900	1900	570	<3.8	<18	<96	160	<4.1	<0.36	<0.38	<0.72	<0.39	<0.38
Chrysene	79000	6200	1900	<3.8	<18	<96	560	12	<0.36	<0.38	<0.72	<0.39	<0.38
Dibenz(a,h)anthracene	79	60	18	<3.8	[<18]	[<96]	**[84]**	<4.1	<0.36	<0.38	<0.72	<0.39	<0.38
Fluoranthene	33000	18000	6300	8.2	23	220	900	34	<0.36	<0.38	1.6	<0.39	<0.38
Fluorene	33000	2300	170	<3.8	<18	**[280]**	<42	11	<0.36	<0.38	0.94	<0.39	<0.38
Indeno(1,2,3-cd)pyrene	790	540	160	<3.8	<18	<96	**[420]**	12	<0.36	<0.38	<0.72	<0.39	<0.38
Naphthalene	17000	170	0.7	**[32]**	**[130]**	**[1100]**	[<42]	[<4.1]	<0.36	<0.38	**[6.3]**	<0.39	<0.38
Phenanthrene	2500	170	13	**[15]**	**[49]**	**[540]**	[<42]	**[41]**	<0.36	<0.38	<0.72	0.41	<0.38
Pyrene	25000	13000	4600	10	31	190	990	30	<0.36	<0.38	<0.72	0.4	<0.38
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	17000	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	77	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	120	38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	230	81	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	32	2.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	53	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	87	31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	0.22	<0.14	0.75	**[35]**	**[11]**	<0.14	<0.28	<0.27	0.33	<0.15
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[41]	Reported above R-MTGW
[35]	Reported above I-MTGW and R-MTGW
[84]	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	I-MTGW	R-MTGW	SB-018 SB-18 10/1/1994 4 Primary	SB-018 SB-18 10/1/1994 8 Primary	SB-019 SB-19 10/1/1994 4 Primary	SB-019 SB-19 10/1/1994 8 Primary	SB-020 SB-20 (2-4) 10/18/1994 4 Primary	SB-020 SB-20 (4-6) 10/18/1994 6 Primary	SB-020 SB-20 (6-7.7) 10/18/1994 7.7 Primary	SB-021 SB-21 10/1/1994 6 Primary	SB-021 SB-21 10/1/1994 10 Primary	SS-01 SS-1 4/3/1996 1 Primary
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	**[0.46]**	[<0.33]	[<0.34]	[<1.5]	[<0.36]	**[0.4]**	[<0.37]	[<0.39]	[<0.35]	[<0.41]
Ethylbenzene	29000	200	13	<0.4	<0.33	<0.34	**[40]**	<0.36	<0.34	<0.37	<0.39	<0.35	<0.41
Toluene	49000	96	12	<0.4	<0.33	<0.34	<1.5	<0.36	<0.34	<0.37	<0.39	<0.35	<0.41
Xylene (total)	4800	430	210	<0.4	<0.33	<0.34	35	<0.36	<0.34	<0.37	<0.39	<0.35	<0.41
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	1800	130	<0.42	<0.35	<7.3	52	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Acenaphthylene	5900	180	18	<0.42	<0.35	10	[<48]	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Anthracene	250000	36000	2700	<0.42	<0.35	9.4	50	<0.77	8.5	<7.8	<4.1	<1.8	<0.43
Benzo(a)anthracene	790	62	19	<0.42	<0.35	**[20]**	**[58]**	<0.77	13	<7.8	<4.1	<1.8	0.49
Benzo(a)pyrene	79	16	8.2	<0.42	<0.35	**[16]**	[<48]	<0.77	**[8.4]**	<7.8	<4.1	<1.8	<0.43
Benzo(b)fluoranthene	790	190	57	<0.42	<0.35	16	<48	<0.77	12	<7.8	<4.1	<1.8	<0.43
Benzo(g,h,i)perylene	NA	NA	NA	<0.42	<0.35	82	<48	<0.77	5	<7.8	<4.1	<1.8	<0.43
Benzo(k)fluoranthene	7900	1900	570	<0.42	<0.35	<7.3	<48	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Chrysene	79000	6200	1900	<0.42	<0.35	20	56	<0.77	11	<7.8	<4.1	<1.8	0.71
Dibenz(a,h)anthracene	79	60	18	<0.42	<0.35	<7.3	[<48]	<0.77	<3.6	<7.8	<4.1	<1.8	<0.43
Fluoranthene	33000	18000	6300	<0.42	<0.35	31	110	<0.77	33	<7.8	<4.1	<1.8	1.2
Fluorene	33000	2300	170	<0.42	<0.35	16	73	<0.77	4.4	<7.8	<4.1	<1.8	<0.43
Indeno(1,2,3-cd)pyrene	790	540	160	<0.42	<0.35	<7.3	<48	<0.77	4.6	<7.8	<4.1	<1.8	<0.43
Naphthalene	17000	170	0.7	<0.42	<0.35	**[10]**	**[170]**	[<0.77]	**[7.4]**	[<7.8]	[<4.1]	[<1.8]	<0.43
Phenanthrene	2500	170	13	<0.42	<0.35	**[79]**	**[340]**	<0.77	**[37]**	<7.8	<4.1	<1.8	0.74
Pyrene	25000	13000	4600	<0.42	<0.35	71	210	<0.77	30	<7.8	<4.1	<1.8	1
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	17000	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	77	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	120	38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	230	81	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	32	2.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	53	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	87	31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	<0.17	<0.14	**[1.9]**	**[1.2]**	**[4]**	**[3.5]**	0.27	<0.31	<0.15	<0.17
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[41]	Reported above R-MTGW
[35]	Reported above I-MTGW and R-MTGW
[84]	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	I-MTGW	R-MTGW	SS-01 SS-1 4/3/1996 2 Primary	SS-02 SS-2 (1-2) 4/3/1996 2 Primary	SS-03 SS-3 4/3/1996 1 Primary	SS-03 SS-3 4/3/1996 1 Duplicate 1	SS-04 SS-4 4/3/1996 0.5 Primary	SS-05 SS-5 4/3/1996 0.5 Primary	SS-06 SS-6 4/3/1996 0.5 Primary	SS-07 SS-7 4/3/1996 2 Primary	SS-08 SS-8 4/3/1996 1.5 Primary	SS-09 SS-9 4/3/1996 2 Primary
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	[<0.38]	[<0.39]	[<0.42]	[<0.38]	[<0.35]	[<0.35]	[<0.33]	[<0.4]	[<0.38]	[<0.38]
Ethylbenzene	29000	200	13	<0.38	<0.39	<0.42	<0.38	<0.35	<0.35	<0.33	<0.4	<0.38	<0.38
Toluene	49000	96	12	<0.38	<0.39	0.64	<0.38	<0.35	0.41	<0.33	<0.4	<0.38	<0.38
Xylene (total)	4800	430	210	<0.38	<0.39	<0.42	<0.38	<0.35	<0.35	<0.33	<0.4	<0.38	<0.38
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	1800	130	<0.4	<0.41	<0.45	<0.41	<0.37	<0.38	<0.35	1.6	<0.4	<0.41
Acenaphthylene	5900	180	18	<0.4	1.9	<0.45	<0.41	<0.37	<0.38	<0.35	4.5	5.1	1
Anthracene	250000	36000	2700	<0.4	1.4	<0.45	<0.41	0.76	1	<0.35	<17	3.3	2
Benzo(a)anthracene	790	62	19	<0.4	12	0.63	<0.41	1.7	2.7	0.38	**[54]**	16	6.4
Benzo(a)pyrene	79	16	8.2	<0.4	3.9	<0.45	<0.41	0.8	1.1	<0.35	**[25]**	**[10]**	4.1
Benzo(b)fluoranthene	790	190	57	<0.4	1.4	0.59	0.41	0.76	1.4	<0.35	27	10	4
Benzo(g,h,i)perylene	NA	NA	NA	<0.4	<0.41	0.88	<0.41	0.67	0.89	<0.35	19	11	3
Benzo(k)fluoranthene	7900	1900	570	<0.4	<0.41	<0.45	<0.41	0.49	0.48	<0.35	<17	2.9	1.5
Chrysene	79000	6200	1900	<0.4	20	0.99	<0.41	2	3.3	0.59	44	23	8.4
Dibenz(a,h)anthracene	79	60	18	<0.4	1.2	<0.45	<0.41	<0.37	<0.38		3.9	1.5	0.73
Fluoranthene	33000	18000	6300	0.52	39	1.1	<0.41	3.6	0.4	0.82	68	26	8.9
Fluorene	33000	2300	170	<0.4	<0.41	<0.45	<0.41	<0.37	<0.38	<0.35	2.3	0.91	0.46
Indeno(1,2,3-cd)pyrene	790	540	160	<0.4	<0.41	0.67	<0.41	0.68	0.9	<0.35	19	<8	2.8
Naphthalene	17000	170	0.7	<0.4	<0.41	<0.45	<0.41	<0.37	<0.38	<0.35	**[3.5]**	0.48	0.57
Phenanthrene	2500	170	13	<0.4	6	<0.45	<0.41	2	2.2	<0.35	**[28]**	**[13]**	4.7
Pyrene	25000	13000	4600	0.52	52	1.3	0.49	4.6	4	0.91	71	56	8.4
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	220000	17000	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	590	77	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	3400	120	38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	970	230	81	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	340	32	2.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	5700	53	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	5700	87	31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	<0.16	**[4.8] ?**	<0.18	0.17	<0.28	<0.28	<0.27	**[3.2]**	**[5]**	<0.31
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared
to Free Cyanide action level

[41]	Reported above R-MTGW
[35]	Reported above I-MTGW and R-MTGW
[84]	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

AECOM

Table 8
Historical Subsurface Soil Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Sample ID Date Depth (ft) CONSTITUENT	CWDC	I-MTGW	R-MTGW	SS-10 SS-10 4/3/1996 2 Primary	SS-11 SS-11 4/3/1996 1.5 Primary	SS-12 SS-12 4/3/1996 1.5 Primary	TS-SB-01 TS-SB-1(17-18') 5/4/2011 18 Primary	TS-SB-02 TS-SB-2(16-18') 5/4/2011 18 Primary	TS-SB-02 TS-SB-2(16-18')FD 5/4/2011 18 Duplicate 1	TS-SB-03 TS-SB-3(17-18.5') 5/4/2011 18.5 Primary	TS-SB-04 TS-SB-4(1-3') 5/4/2011 3 Primary	TS-SB-05 TS-SB-5(20-21') 5/4/2011 21 Primary	TS-SB-06 TS-SB-6(16-18') 5/4/2011 18 Primary
BTEX (mg/Kg)													
Benzene	560	0.35	0.034	**[0.37]**	[<0.36]	[<0.38]	**[72]**	**[1.6]**	**[7.9]**	[<0.5]	<0.0045	**[2.1]**	<0.0052
Ethylbenzene	29000	200	13	<0.37	<0.36	<0.38	**[160]**	**[13]**	**[160]**	1.5	<0.0045	**[20]**	<0.0052
Toluene	49000	96	12	<0.37	0.75	<0.38	**[22]**	<0.84	11	0.88	<0.0045	<0.52	<0.0052
Xylene (total)	4800	430	210	<0.37	1.3	<0.38	180	7.9	180	3.3	<0.009	8.4	0.04
PAHs (mg/Kg)													
2-Methylnaphthalene	3300	42	3.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50000	1800	130	3.2	<0.38	<0.41	8.9	19	36	1.2	<0.36	36	<0.37
Acenaphthylene	5900	180	18	3.1	<0.38	<0.41	0.51	<4.4	<4.9	<0.42	<0.36	<3.8	<0.37
Anthracene	250000	36000	2700	<19	<0.38	<0.41	3.3	23	40	2.1	<0.36	17	<0.37
Benzo(a)anthracene	790	62	19	**[44]**	<0.38	0.96	2.1	**[23]**	**[46]**	0.66	<0.36	10	<0.37
Benzo(a)pyrene	79	16	8.2	[<19]	<0.38	1.4	1.7	**[19]**	**[42]**	0.57	<0.36	**[10]**	<0.37
Benzo(b)fluoranthene	790	190	57	<19	<0.38	1.2	0.74	15	33	<0.42	<0.36	5.4	<0.37
Benzo(g,h,i)perylene	NA	NA	NA	6.3	<0.38	0.72	0.59	7.4	22	<0.42	<0.36	5	<0.37
Benzo(k)fluoranthene	7900	1900	570	3.7	<0.38	0.42	0.88	15	37	0.45	<0.36	6.5	<0.37
Chrysene	79000	6200	1900	44	<0.38	1	2.2	25	55	0.59	<0.36	10	<0.37
Dibenz(a,h)anthracene	79	60	18	2.3	<0.38	<0.41	<0.4	<4.4	8.8	<0.42	<0.36	<3.8	<0.37
Fluoranthene	33000	18000	6300	59	<0.38	1.8	3.5	47	140	1.5	<0.36	24	<0.37
Fluorene	33000	2300	170	4.2	<0.38	<0.41	4.8	28	66	3.3	<0.36	15	<0.37
Indeno(1,2,3-cd)pyrene	790	540	160	<19	<0.38	0.56	0.46	7.1	21	<0.42	<0.36	<3.8	<0.37
Naphthalene	17000	170	0.7	**[3.1]**	<0.38	<0.41	**[44]**	**[46]**	**[160]**	**[14]**	<0.36	**[170]**	<0.37
Phenanthrene	2500	170	13	**[41]**	<0.38	1.1	**[18]**	**[86]**	**[210]**	3.4	<0.36	**[80]**	<0.37
Pyrene	25000	13000	4600	80	<0.38	2.6	6.6	48	100	1.8	<0.36	36	<0.37
Metals (mg/Kg)													
Arsenic	320	5.8	5.8	NA	NA	NA	**[6.1]**	**[8.8]**	**[15]**	5.2	4.9	4.4	4.6
Barium	220000	17000	1600	NA	NA	NA	57	110	97	66	22	44	40
Cadmium	590	77	7.5	NA	NA	NA	<0.61	<0.64	0.96	<0.59	<0.51	<0.56	<0.51
Chromium	3400	120	38	NA	NA	NA	16	9.4	9.8	19	6.3	12	9.2
Lead	970	230	81	NA	NA	NA	9.4	**[580]**	**[1500]**	11	5	6.8	5.7
Mercury	340	32	2.1	NA	NA	NA	<0.015	0.12	4.3	0.054	<0.022	0.018	<0.016
Selenium	5700	53	5.2	NA	NA	NA	<1.2	<1.3	<1.4	<1.2	<1	<1.1	<1
Silver	5700	87	31	NA	NA	NA	<1.2	<1.3	<1.4	<1.2	<1	<1.1	<1
Cyanide (mg/Kg)													
Cyanide, Total**	23000	9.6	0.94	**[1.4]**	<0.29	**[0.95]**	NA	NA	NA	NA	NA	NA	NA
Cyanide, WAD	23000	9.6	0.94	NA	NA	NA	<0.16	<0.17	0.27	0.21	<0.14	<0.15	<0.15

Notes:
mg/Kg = milligram per kilogram
NA = Not Analyzed
ft = feet
** - Total Cyanide results compared to Free Cyanide action level

[41]	Reported above R-MTGW
[35]	Reported above I-MTGW and R-MTGW
[84]	Reported above CWDC, I-MTGW and R-MTGW
[<84]	Nonbold indicates reporting limit above action level

Table 9
Historical Ground Water Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Date CONSTITUENT	Ground Water IDCL	Ground Water RDCL	MW-001 10/31/1994 Primary	MW-001 12/12/1994 Primary	MW-001 3/14/1995 Primary	MW-002 10/31/1994 Primary	MW-002 10/31/1994 Duplicate	MW-002 12/12/1994 Primary	MW-002 12/12/1994 Duplicate	MW-002 3/14/1995 Primary
BTEX (µg/L)										
Benzene	52	5	**[480]**	**[480]**	**[470]**	**[6100]**	**[5900]**	**[5100]**	**[5100]**	**[7200]**
Ethylbenzene	10000	700	480	470	480	310	320	**[1700]**	<5	<5
Toluene	8200	1000	51	<5	<5	**[1800]**	**[1800]**	<5	**[1400]**	**[2700]**
Xylenes (total)	20000	10000	350	260	380	750	760	<5	<5	600
m/p-xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs (µg/L)										
2-Methylnaphthalene	410	31	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	6100	460	**[730]**	**[2200]**	**[1500]**	<200	<200	<10	<10	<10
Acenaphthylene	730	71	[<400]	<10	<10	[<200]	[<200]	<10	<10	<10
Anthracene	31000	2300	<400	830	360	<200	<200	<10	<10	<10
Benzo(a)anthracene	3.9	1.2	[<400]	[<10]	[<10]	[<200]	[<200]	[<10]	[<10]	[<10]
Benzo(a)pyrene	0.39	0.2	[<400]	[<10]	[<10]	[<200]	[<200]	[<10]	[<10]	[<10]
Benzo(b)fluoranthene	3.9	1.2	[<400]	[<10]	[<10]	[<200]	[<200]	[<10]	[<10]	[<10]
Benzo(g,h,i)perylene	NA	NA	<400	<10	<10	<200	<200	<10	<10	<10
Benzo(k)fluoranthene	39	12	[<400]	<10	<10	[<200]	[<200]	<10	<10	<10
Chrysene	390	120	[<400]	<10	**[210]**	[<200]	[<200]	<10	<10	<10
Dibenz(a,h)anthracene	0.39	0.12	[<400]	[<10]	[<10]	[<200]	[<200]	[<10]	[<10]	[<10]
Fluoranthene	4100	1500	<400	1100	530	<200	<200	<10	<10	<10
Fluorene	4100	310	[<400]	**[1000]**	**[490]**	<200	<200	<10	<10	<10
Indeno(1,2,3-cd)pyrene	3.9	1.2	[<400]	[<10]	[<10]	[<200]	[<200]	[<10]	[<10]	[<10]
Naphthalene	2000	8.3	**[4900]**	**[4600]**	**[2200]**	**[1700]**	**[1700]**	**[2200]**	**[1900]**	**[580]**
Phenanthrene	310	23	**[630]**	**[2900]**	**[1800]**	[<200]	[<200]	<10	<10	<10
Pyrene	3100	1100	<400	**[1700]**	**[1820]**	<200	<200	<10	<10	<10
Metals (µg/L)										
Arsenic	10	10	NA	NA	NA	NA	NA	NA	NA	NA
Barium	20000	2000	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	51	5	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	42	15	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	510	50	NA	NA	NA	NA	NA	NA	NA	NA
Silver	510	180	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide (µg/L)										
Cyanide, Total**	2000	200	**[410]**	**[470]**	**[500]**	**[350]**	<10.0	**[330]**	**[390]**	**[310]**
Cyanide, WAD	2000	200	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
µg/L = microgram per liter
NA = Not Analyzed
** - Total Cyanide results compared
to Free Cyanide action level

[730]	Reported above GW-RDCL
[480]	Reported above GW-RDCL and GW-IDCL
[<400]	Nonbold indicates reporting limit above action level

AECOM

Site Date CONSTITUENT	Ground Water IDCL	Ground Water RDCL	MW-002 3/14/1995 Duplicate	MW-002 5/11/2011 Primary	MW-003 10/31/1994 Primary	MW-003 12/12/1994 Primary	MW-003 3/14/1995 Primary	MW-003 5/11/2011 Primary	MW-004 10/31/1994 Primary	MW-004 12/12/1994 Primary
BTEX (µg/L)										
Benzene	52	5	**[6500]**	**[1400]**	**[82]**	[<5]	[<5]	[<5]	**[2900]**	**[3100]**
Ethylbenzene	10000	700	<5	140	520	55	17	<5	**[2200]**	**[1900]**
Toluene	8200	1000	**[2200]**	530	370	22	<5	<5	800	**[1200]**
Xylenes (total)	20000	10000	510	320	800	86	26	<10	2200	1300
m/p-xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs (µg/L)										
2-Methylnaphthalene	410	31	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	6100	460	<10	2	**[470]**	370	<10	51	[<1000]	160
Acenaphthylene	730	71	41	6.2	[<200]	65	<10	2.4	[<1000]	20
Anthracene	31000	2300	<10	0.37	280	240	40	3.6	<1000	22
Benzo(a)anthracene	3.9	1.2	[<10]	<0.1	[<200]	**[190]**	[<10]	0.63	[<1000]	[<10]
Benzo(a)pyrene	0.39	0.2	[<10]	<0.1	[<200]	**[71]**	[<10]	**[0.52]**	[<1000]	[<10]
Benzo(b)fluoranthene	3.9	1.2	[<10]	0.17	[<200]	**[72]**	[<10]	0.41	[<1000]	[<10]
Benzo(g,h,i)perylene	NA	NA	<10	<0.1	<200	<10	<10	0.13	<1000	<10
Benzo(k)fluoranthene	39	12	<10	<0.1	[<200]	<10	<10	0.27	[<1000]	<10
Chrysene	390	120	<10	<0.1	[<200]	**[150]**	<10	0.54	[<1000]	<10
Dibenz(a,h)anthracene	0.39	0.12	[<10]	<0.1	[<200]	[<10]	[<10]	<0.1	[<1000]	[<10]
Fluoranthene	4100	1500	<10	0.35	360	300	62	3.8	<1000	<10
Fluorene	4100	310	<10	3.4	**[340]**	**[320]**	81	24	[<1000]	75
Indeno(1,2,3-cd)pyrene	3.9	1.2	[<10]	<0.02	[<200]	[<10]	[<10]	0.11	[<1000]	[<10]
Naphthalene	2000	8.3	**[450]**	**[400]**	**[1800]**	**[450]**	**[140]**	4.9	**[11000]**	**[4000]**
Phenanthrene	310	23	**[47]**	1	**[880]**	**[670]**	**[210]**	**[34]**	[<1000]	**[82]**
Pyrene	3100	1100	<10	0.3	440	470	78	2.6	<1000	<10
Metals (µg/L)										
Arsenic	10	10	NA	**[12]**	NA	NA	NA	[<10]	NA	NA
Barium	20000	2000	NA	55	NA	NA	NA	61	NA	NA
Cadmium	51	5	NA	[<5]	NA	NA	NA	[<5]	NA	NA
Chromium	NA	NA	NA	<10	NA	NA	NA	<10	NA	NA
Lead	42	15	NA	<10	NA	NA	NA	<10	NA	NA
Mercury	NA	NA	NA	<0.2	NA	NA	NA	<0.2	NA	NA
Selenium	510	50	NA	<10	NA	NA	NA	<10	NA	NA
Silver	510	180	NA	<10	NA	NA	NA	<10	NA	NA
Cyanide (µg/L)										
Cyanide, Total**	2000	200	**[310]**	NA	**[250]**	190	170	NA	120	84
Cyanide, WAD	2000	200	NA	5.4	NA	NA	NA	6.2	NA	NA

Notes:
µg/L = microgram per liter
NA = Not Analyzed
** - Total Cyanide results compared
to Free Cyanide action level

[730]	Reported above GW-RDCL
[480]	Reported above GW-RDCL and GW-IDCL
[<400]	Nonbold indicates reporting limit above action level

Table 9
Historical Ground Water Analytical Results
Richmond Former Manufactured Gas Plant Site
Brownfields Number 4980004

Site Date CONSTITUENT	Ground Water IDCL	Ground Water RDCL	MW-004 3/14/1995 Primary	MW-004 5/11/2011 Primary	MW-004 5/11/2011 Duplicate	MW-006 5/11/2011 Primary	MW-008 5/11/2011 Primary	MW-101 10/17/1995 Primary	MW-101 12/21/1995 Primary	MW-101 12/21/1995 Duplicate
BTEX (µg/L)										
Benzene	52	5	[3600]	[2200]	[2000]	[1300]	[<5]	[<5]	NA	NA
Ethylbenzene	10000	700	[2100]	[4200]	[4000]	[1200]	<5	6	NA	NA
Toluene	8200	1000	[1200]	640	620	82	<5	<5	NA	NA
Xylenes (total)	20000	10000	2200	3800	3800	880	<10	14	NA	NA
m/p-xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs (µg/L)										
2-Methylnaphthalene	410	31	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	6100	460	<10	270	300	96	14	[601]	[1100]	330
Acenaphthylene	730	71	<10	11	15	5.8	0.15	[<100]	[130]	38
Anthracene	31000	2300	<10	32	43	35	0.23	190	430	100
Benzo(a)anthracene	3.9	1.2	[<10]	[12]	[25]	[28]	0.63	[110]	[280]	[63]
Benzo(a)pyrene	0.39	0.2	[<10]	[9]	[22]	[36]	[0.8]	[<100]	[260]	[<10]
Benzo(b)fluoranthene	3.9	1.2	[<10]	[6.2]	[14]	[19]	0.47	[<100]	[190]	[35]
Benzo(g,h,i)perylene	NA	NA	<10	6.8	10	24	0.28	<100	160	31
Benzo(k)fluoranthene	39	12	<10	4.4	[12]	[19]	0.32	[<100]	[<100]	[12]
Chrysene	390	120	<10	13	23	29	0.58	110	[220]	56
Dibenz(a,h)anthracene	0.39	0.12	[<10]	[2.4]	[4]	[5.4]	<0.1	[<100]	[<100]	[<10]
Fluoranthene	4100	1500	<10	37	74	68	2.3	260	680	130
Fluorene	4100	310	<10	94	110	42	0.43	220	[530]	130
Indeno(1,2,3-cd)pyrene	3.9	1.2	[<10]	[4.6]	[7.6]	[15]	0.2	[160]	[<100]	[19]
Naphthalene	2000	8.3	[2700]	[11000]	[14000]	[1200]	0.12	[<100]	[<100]	[<10]
Phenanthrene	310	23	<10	[150]	[200]	[110]	<0.1	[700]	[1400]	[330]
Pyrene	3100	1100	<10	56	71	98	2.1	360	820	170
Metals (µg/L)										
Arsenic	10	10	NA	[<10]	[10]	[<10]	[<10]	NA	NA	NA
Barium	20000	2000	NA	360	400	72	180	NA	NA	NA
Cadmium	51	5	NA	[<5]	[<5]	[<5]	[<5]	NA	NA	NA
Chromium	NA	NA	NA	<10	<10	<10	<10	NA	NA	NA
Lead	42	15	NA	<10	<10	<10	<10	NA	NA	NA
Mercury	NA	NA	NA	<0.2	<0.2	<0.2	<0.2	NA	NA	NA
Selenium	510	50	NA	<10	<10	<10	<10	NA	NA	NA
Silver	510	180	NA	<10	<10	<10	<10	NA	NA	NA
Cyanide (µg/L)										
Cyanide, Total**	2000	200	93	NA	NA	NA	NA	<5.0	NA	NA
Cyanide, WAD	2000	200	NA	<5	<5	19	21	NA	NA	NA

Notes:
µg/L = microgram per liter
NA = Not Analyzed
** - Total Cyanide results compared
to Free Cyanide action level

[730]	Reported above GW-RDCL
[480]	Reported above GW-RDCL and GW-IDCL
[<400]	Nonbold indicates reporting limit above action level

Site Date CONSTITUENT	Ground Water IDCL	Ground Water RDCL	MW-102 10/17/1995 Primary	MW-102 10/17/1995 Duplicate	MW-102 12/21/1995 Primary	MW-102 4/3/1996 Primary	MW-102 4/3/1996 Duplicate
BTEX (µg/L)							
Benzene	52	5	[<5]	[<5]	NA	[<5]	[<5]
Ethylbenzene	10000	700	<5	<5	NA	<5	<5
Toluene	8200	1000	<5	<5	NA	<5	<5
Xylenes (total)	20000	10000	<5	<5	NA	<5	<5
m/p-xylene	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA
PAHs (µg/L)							
2-Methylnaphthalene	410	31	NA	NA	NA	NA	NA
Acenaphthene	6100	460	<10	<10	<10	<10	<10
Acenaphthylene	730	71	<10	<10	<10	<10	<10
Anthracene	31000	2300	<10	<10	<10	<10	<10
Benzo(a)anthracene	3.9	1.2	[<10]	[<10]	[<10]	[<10]	[<10]
Benzo(a)pyrene	0.39	0.2	[<10]	[<10]	[<10]	[<10]	[<10]
Benzo(b)fluoranthene	3.9	1.2	[<10]	[<10]	[<10]	[<10]	[<10]
Benzo(g,h,i)perylene	NA	NA	<10	<10	<10	<10	<10
Benzo(k)fluoranthene	39	12	<10	<10	<10	<10	<10
Chrysene	390	120	<10	<10	<10	<10	<10
Dibenz(a,h)anthracene	0.39	0.12	[<10]	[<10]	[<10]	[<10]	[<10]
Fluoranthene	4100	1500	<10	<10	<10	<10	<10
Fluorene	4100	310	<10	<10	<10	<10	<10
Indeno(1,2,3-cd)pyrene	3.9	1.2	[<10]	[<10]	[<10]	[<10]	[<10]
Naphthalene	2000	8.3	[<10]	[<10]	[<10]	[<10]	[<10]
Phenanthrene	310	23	<10	<10	<10	<10	<10
Pyrene	3100	1100	<10	<10	<10	<10	<10
Metals (µg/L)							
Arsenic	10	10	NA	NA	NA	NA	NA
Barium	20000	2000	NA	NA	NA	NA	NA
Cadmium	51	5	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA
Lead	42	15	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA
Selenium	510	50	NA	NA	NA	NA	NA
Silver	510	180	NA	NA	NA	NA	NA
Cyanide (µg/L)							
Cyanide, Total**	2000	200	47	35	NA	20	<50.0
Cyanide, WAD	2000	200	NA	NA	NA	NA	NA

Notes:
µg/L = microgram per liter
NA = Not Analyzed
** - Total Cyanide results compared
to Free Cyanide action level

[730]	Reported above GW-RDCL
[480]	Reported above GW-RDCL and GW-IDCL
[<400]	Nonbold indicates reporting limit above action level

Figures

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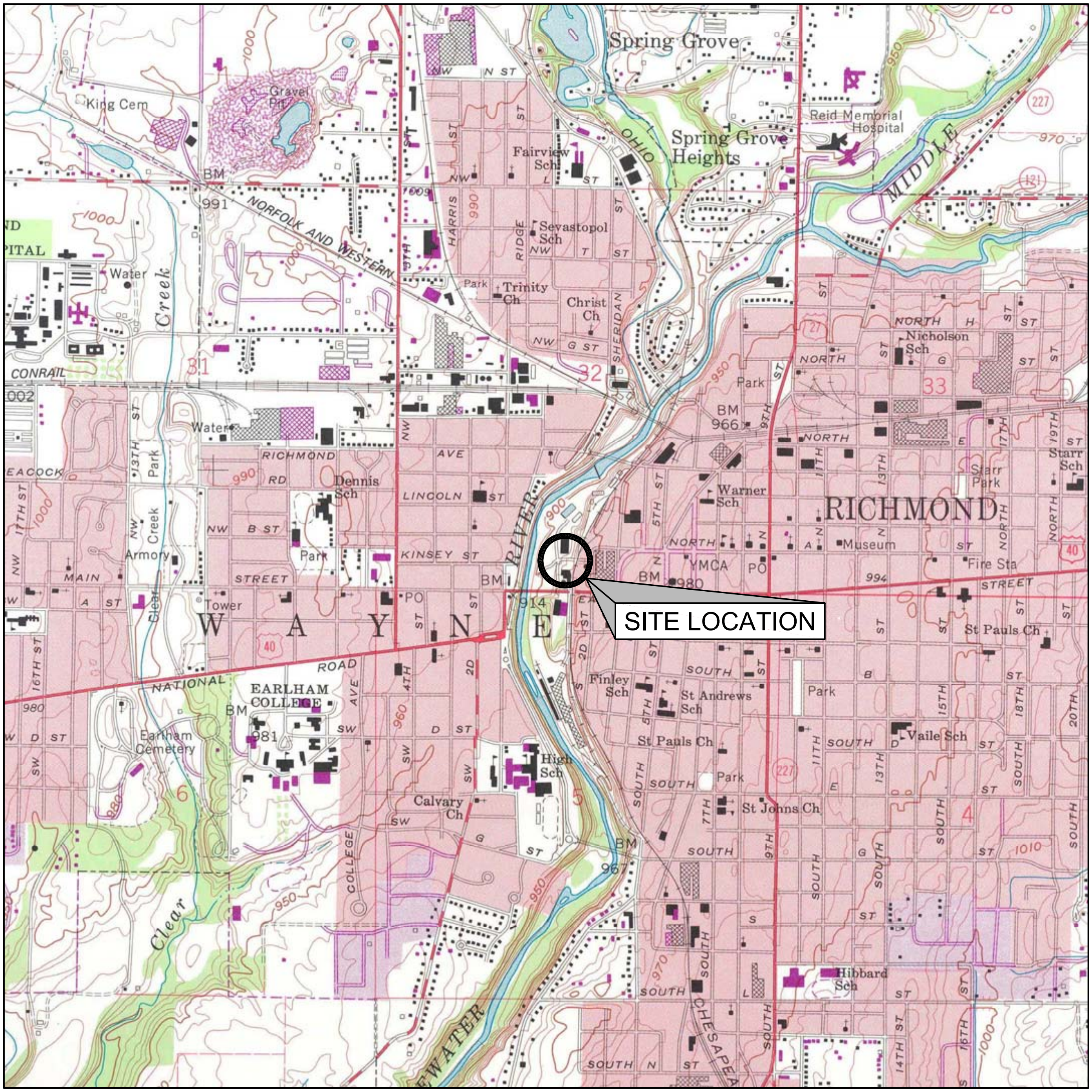
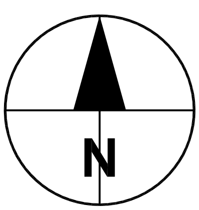
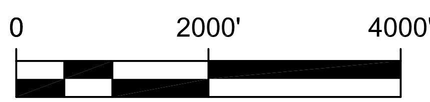


BASE TAKEN FROM USGS RICHMOND, IND.
7.5'-SERIES TOPOGRAPHIC QUADRANGLE.
DATE 1981. SCALE 1:24,000.





1" = 2000'

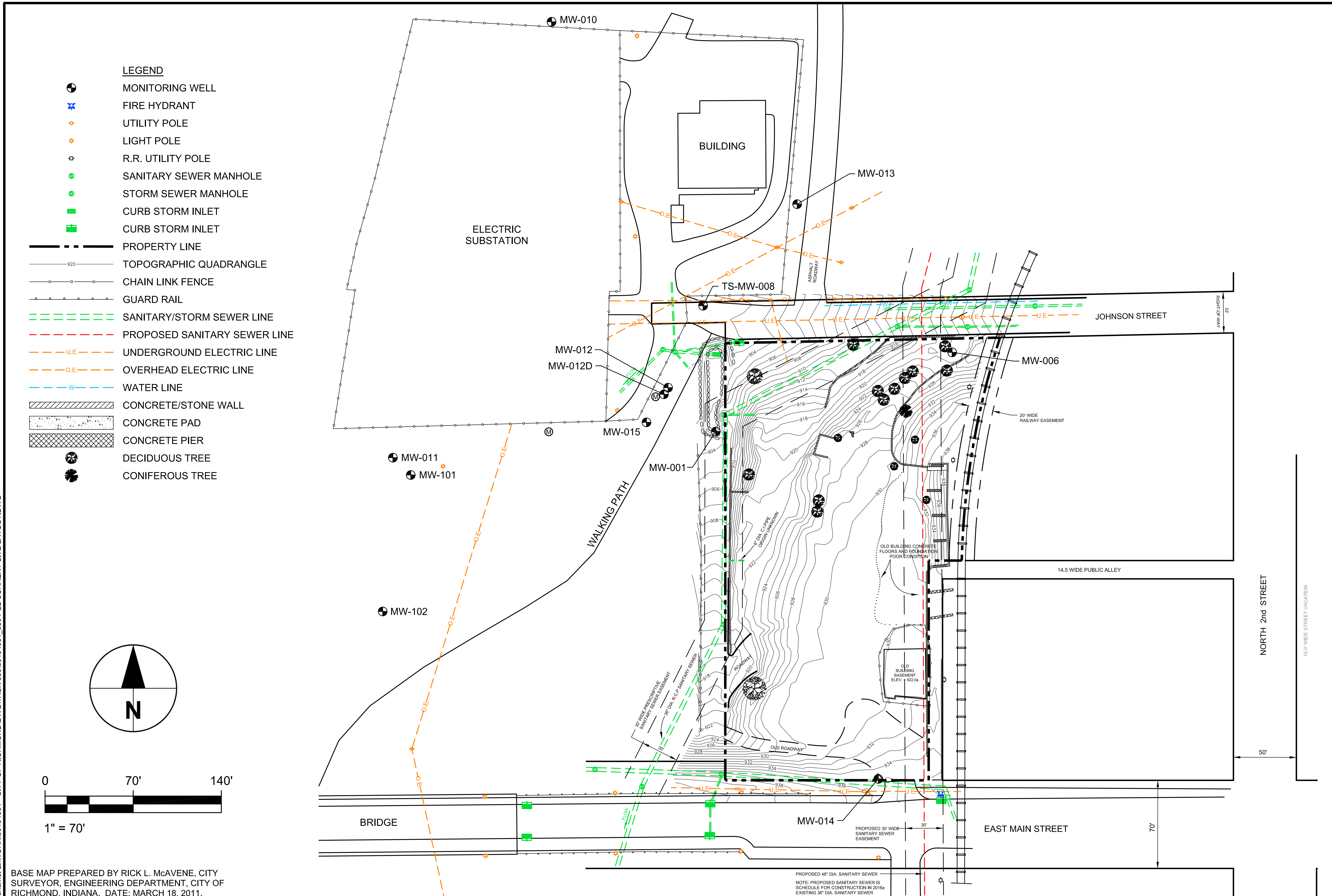
FORMER MGP SITE
RICHMOND, INDIANA

SITE LOCATION MAP

AECOM

Project No.: 60194081 Date: 2012-09-20

Figure: 1



AECOM

Figure: 2

CURRENT SITE LAYOUT

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-20

ANSI B 11" x 17" Approved: Checked: NC Designer: NLW Project Management Initials:

Last saved by: WILZBACHERN(2012-09-21) Last Plotted: 2012-09-21
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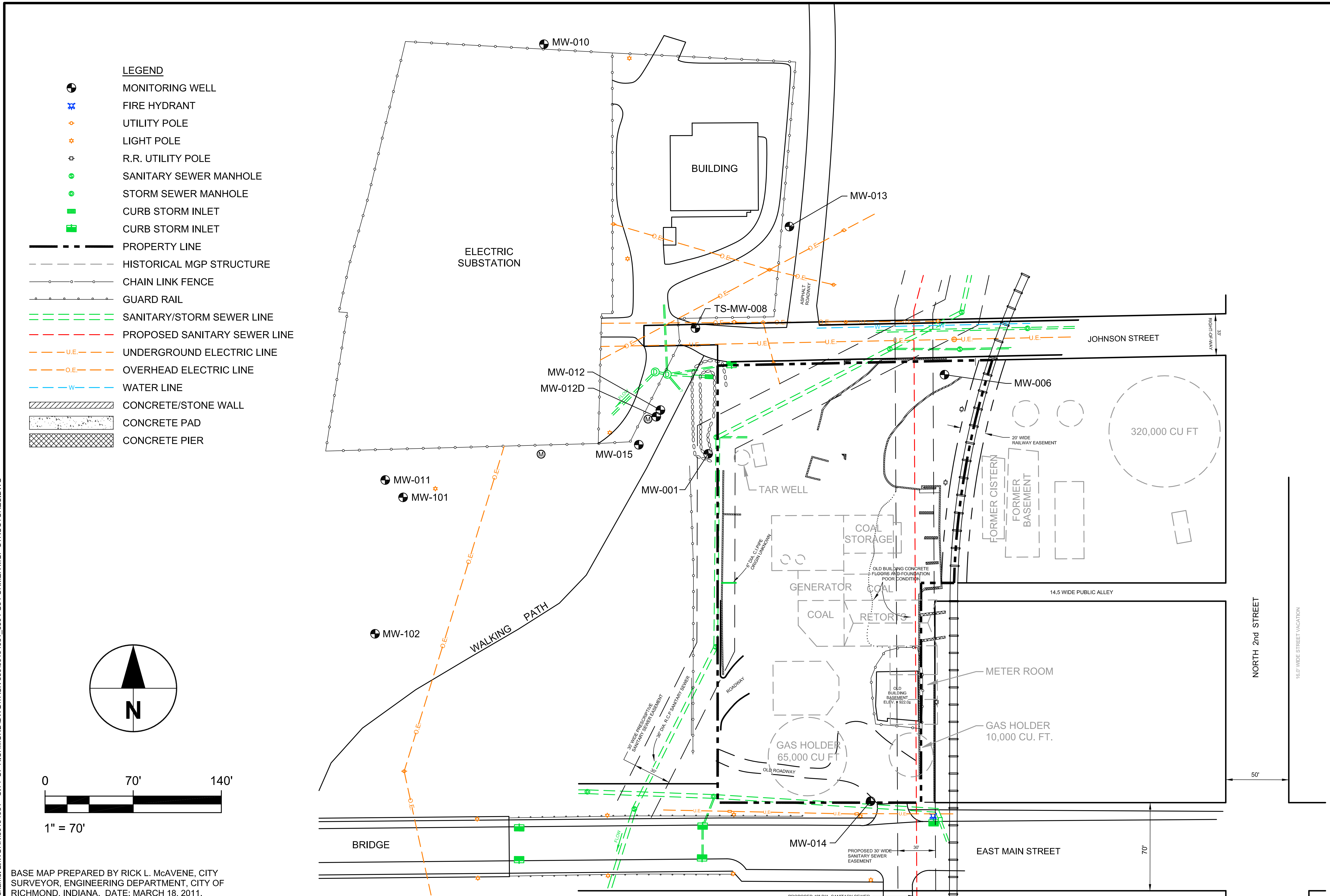

AECOM

Figure: 3

SITE LAYOUT WITH FORMER MGP STRUCTURES

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

ANSI B 11" x 17"
Approved:____ Checked: NC Designer: NLW Project Management Initials:

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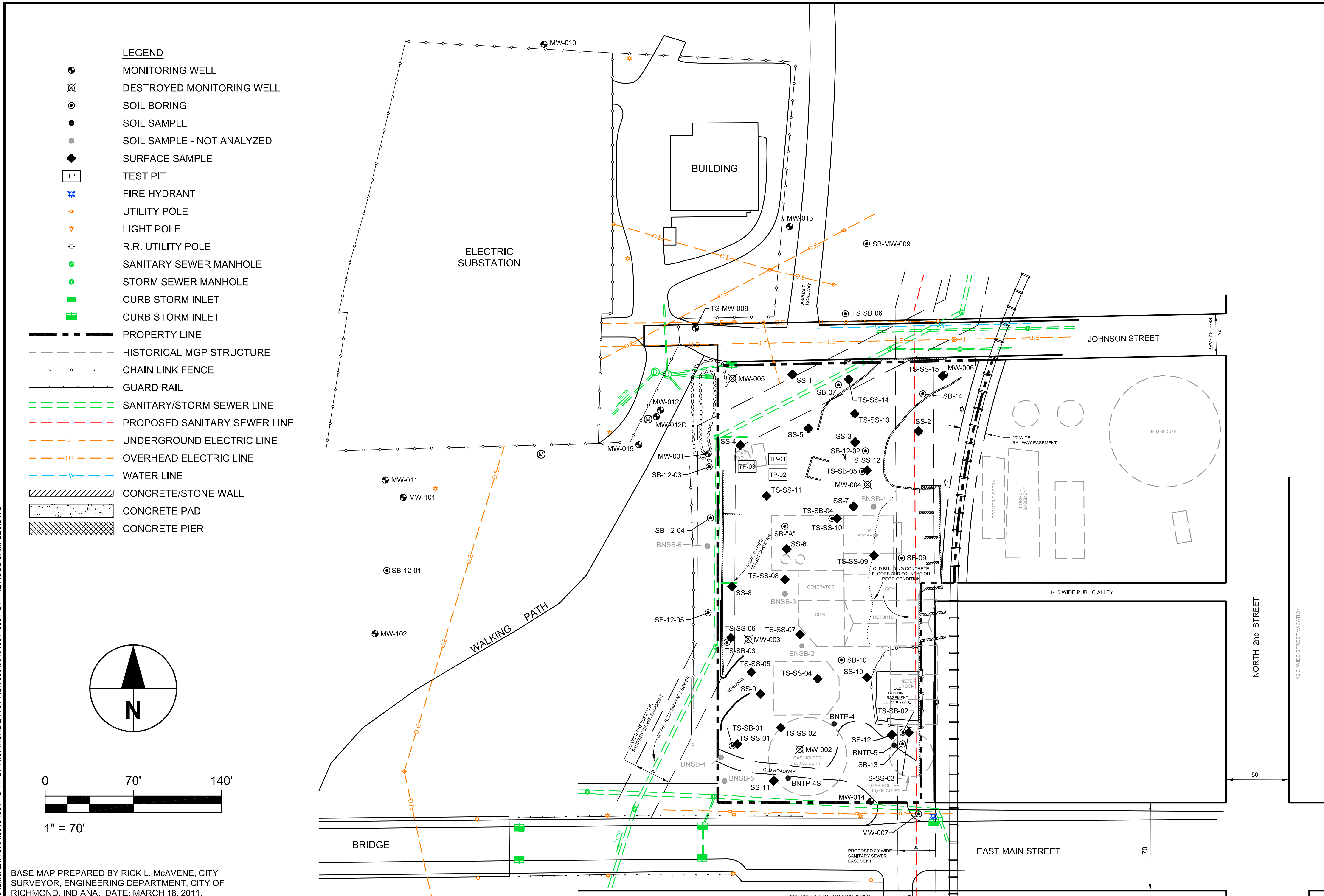
ANSI B 11" x 17"
Approved: ____
Checked: NC
Designer: NLW
Project Management Initials:



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Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG4 PREVIOUS SAMPLES.DWG

AECOM

Figure: 4

ALL SAMPLING LOCATIONS

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

Figure: 5

EXCEEDANCES OF RISC DCLs IN SOIL
AUGUST 2012

AECOM

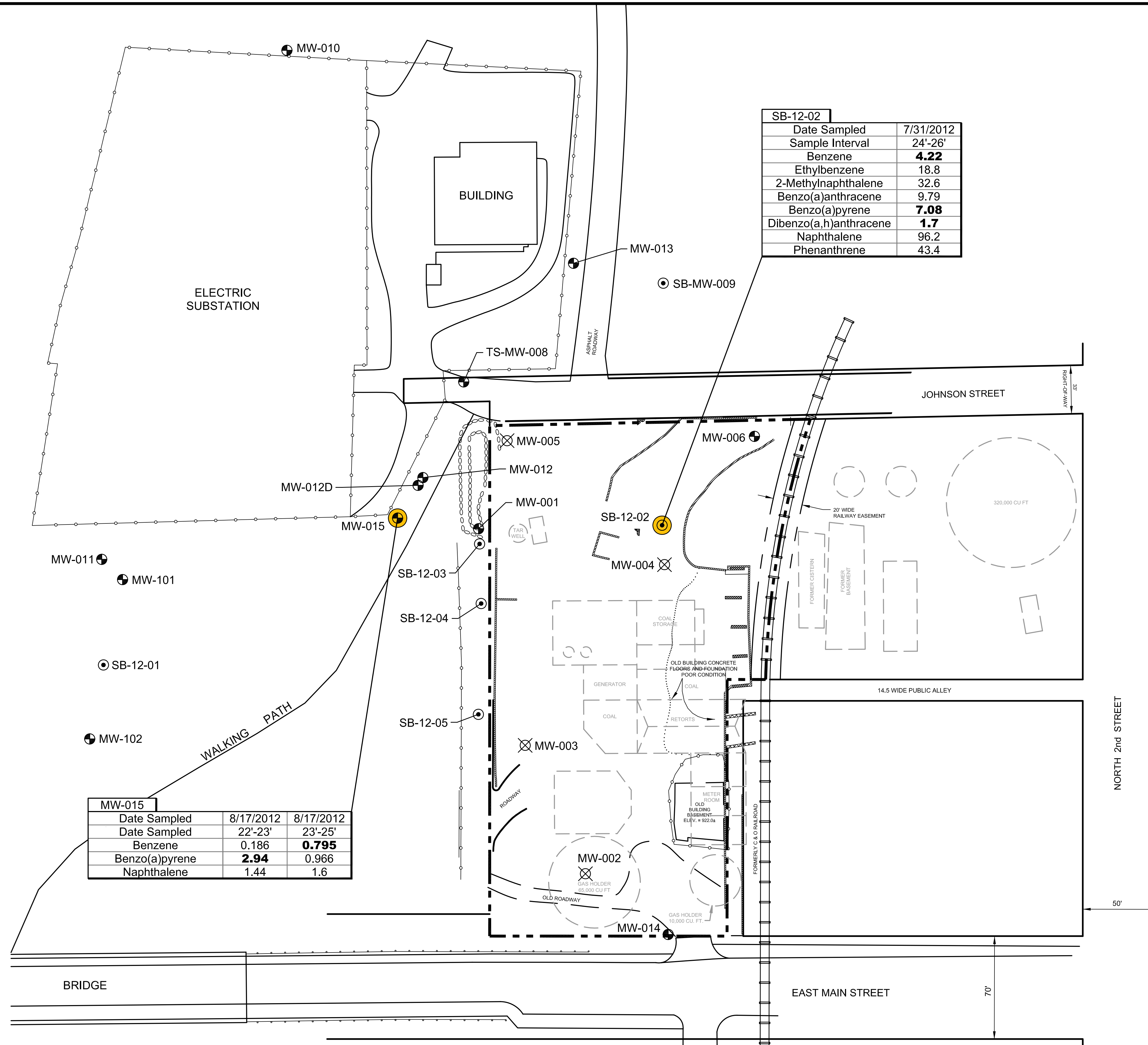
FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

LEGEND
- MONITORING WELL
- DESTROYED MONITORING WELL
- SOIL BORING
- RESIDENTIAL EXCEEDANCES
- INDUSTRIAL EXCEEDANCES
- PROPERTY LINE
- HISTORICAL MGP STRUCTURE
- CHAIN LINK FENCE
- GUARD RAIL
- CONCRETE/STONE WALL
- CONCRETE PAD
- CONCRETE PIER

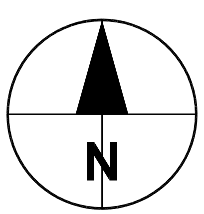
Constituents	RISC Residential Default Closure Level	RISC Industrial Default Closure Level
Benzene	0.034	**0.35**
Ethylbenzene	13	**160**
2-Methylnaphthalene	16	**210**
Benzo(a)anthracene	5	**15**
Benzo(a)pyrene	0.5	**1.5**
Dibenzo(a,h)anthracene	0.5	**1.5**
Naphthalene	0.7	**170**
Phenanthrene	13	**170**

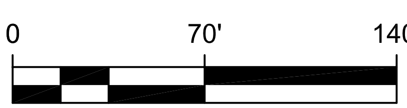
NOTES:
1. ALL ANALYTICAL RESULTS ARE MEASURED IN mg/kg.
2. A BOLD CONCENTRATION DENOTES A RISC INDUSTRIAL DEFAULT CLOSURE LEVEL EXCEEDANCE.



SB-12-02	
Date Sampled	7/31/2012
Sample Interval	24'-26'
Benzene	**4.22**
Ethylbenzene	18.8
2-Methylnaphthalene	32.6
Benzo(a)anthracene	9.79
Benzo(a)pyrene	**7.08**
Dibenzo(a,h)anthracene	**1.7**
Naphthalene	96.2
Phenanthrene	43.4

MW-015		
Date Sampled	8/17/2012	8/17/2012
Date Sampled	22'-23'	23'-25'
Benzene	0.186	**0.795**
Benzo(a)pyrene	**2.94**	0.966
Naphthalene	1.44	1.6





1" = 70'

BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

Project Management Initials: Designer: NLW Checked: NC Approved: ____ ANSI B 11" x 17"

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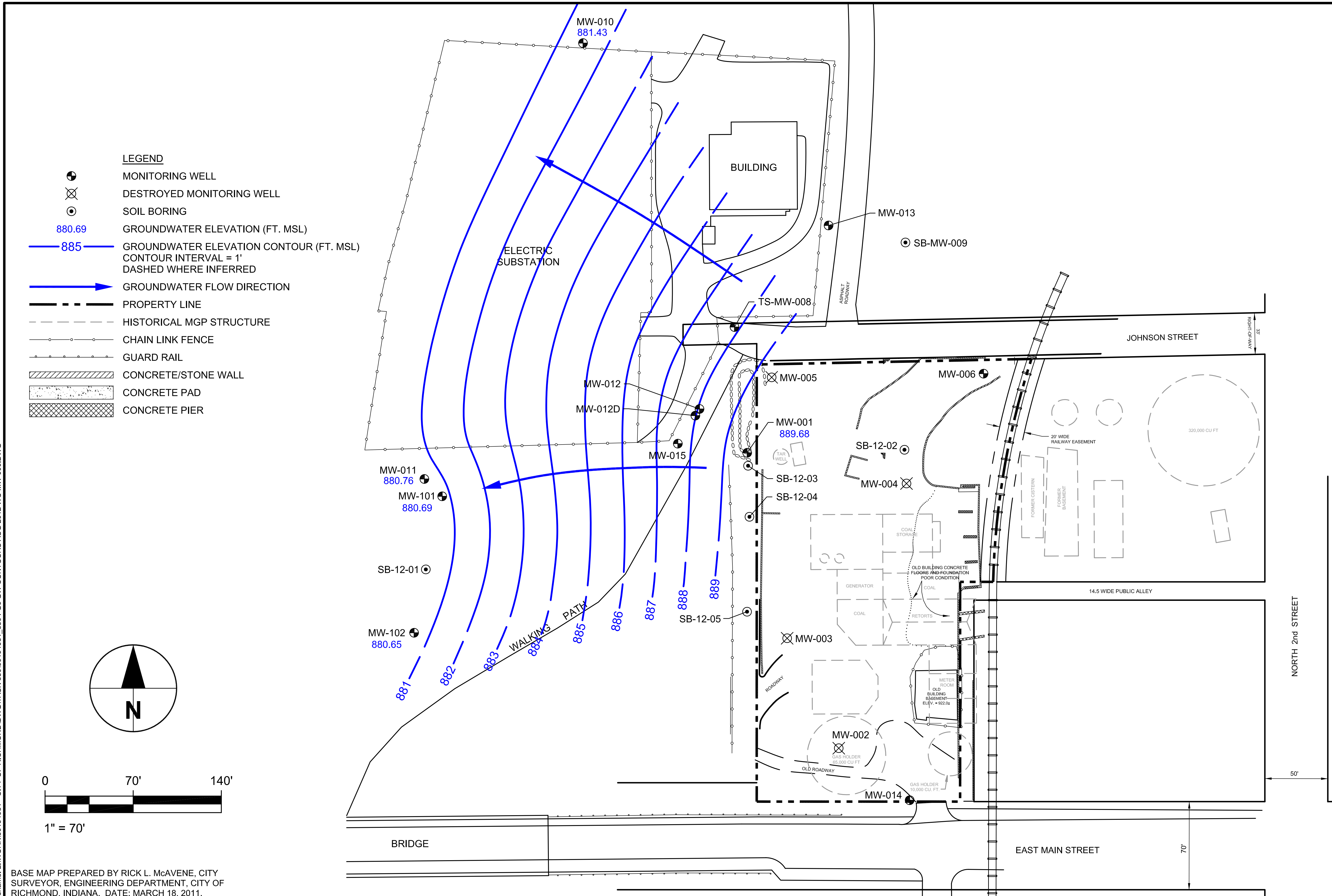


BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

AECOM

Figure: 6

POTENTIOMETRIC SURFACE MAP
AUGUST 2012

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

ANSI B 11" x 17" Approved: ____ Checked: NC Designer: NLW Project Management Initials:

Last saved by: WILZBACHERN(2012-09-27) Last Plotted: 2012-09-27
Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG6 GW CONTOURS AUG 2012 WO MW-006.DWG

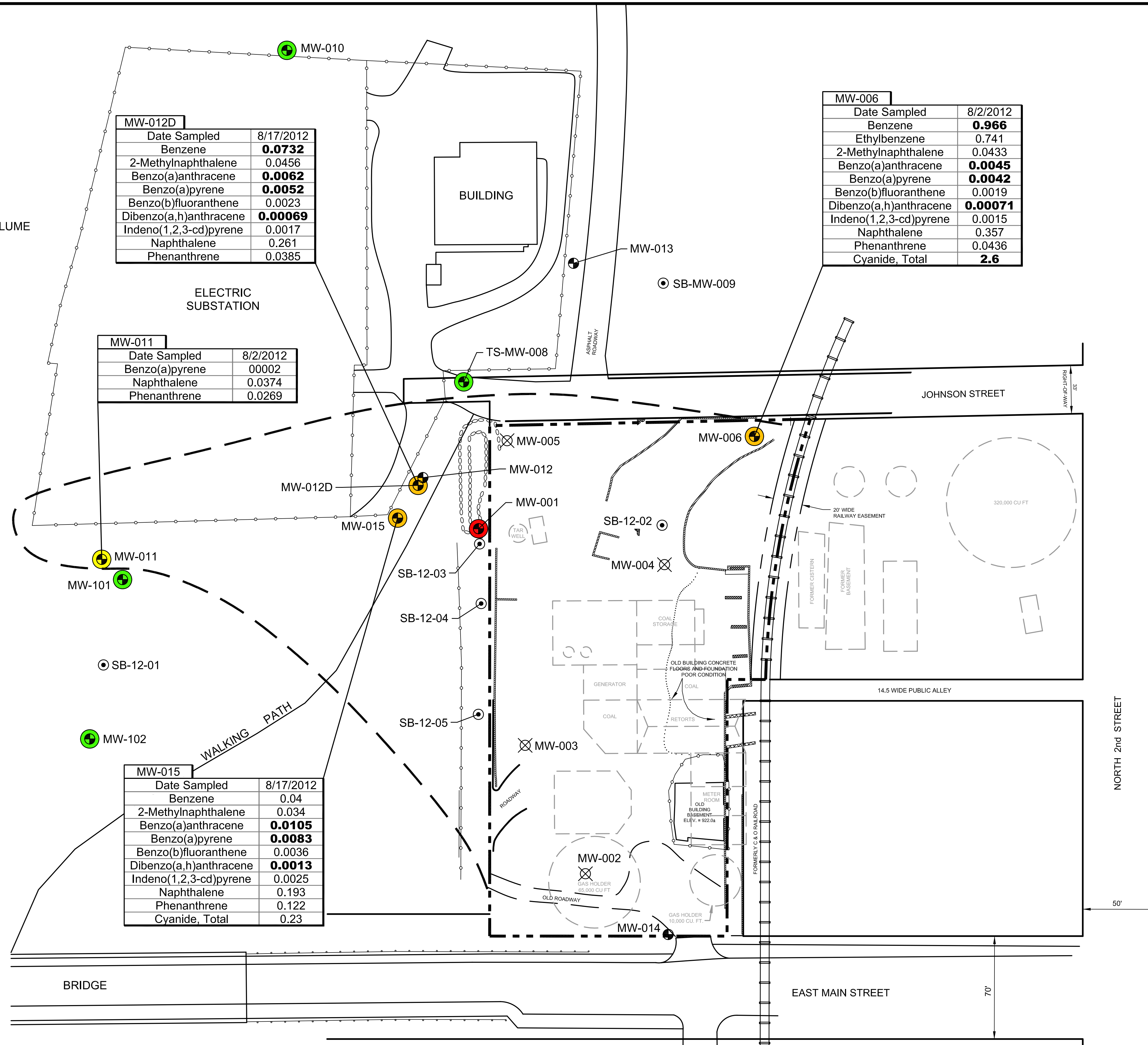
LEGEND

- MONITORING WELL
- DESTROYED MONITORING WELL
- SOIL BORING
- NO EXCEEDANCES
- RESIDENTIAL EXCEEDANCES
- INDUSTRIAL EXCEEDANCES
- LNAPL PRESENT IN WELL
- APPROXIMATE EXTENT OF CONTAMINANT PLUME
- PROPERTY LINE
- HISTORICAL MGP STRUCTURE
- CHAIN LINK FENCE
- GUARD RAIL
- CONCRETE/STONE WALL
- CONCRETE PAD
- CONCRETE PIER

Constituents	RISC Residential Default Groundwater Level	RISC Industrial Default Groundwater Level
Benzene	0.005	**0.052**
Ethylbenzene	0.7	**10**
2-Methylnaphthalene	0.031	**0.41**
Benzo(a)anthracene	0.0012	**0.0039**
Benzo(a)pyrene	0.0002	**0.00039**
Benzo(b)fluoranthene	0.0012	**0.0039**
Dibenzo(a,h)anthracene	0.00012	**0.00039**
Indeno(1,2,3-cd)pyrene	0.0012	**0.0039**
Naphthalene	0.0083	**2**
Phenanthrene	0.023	**0.31**
Cyanide, Total	0.2	**2**

NOTES:

1. ALL ANALYTICAL RESULTS ARE MEASURED IN mg/L.
2. A BOLD CONCENTRATION DENOTES A RISC INDUSTRIAL DEFAULT GROUNDWATER EXCEEDANCE.



MW-012D	
Date Sampled	8/17/2012
Benzene	**0.0732**
2-Methylnaphthalene	0.0456
Benzo(a)anthracene	**0.0062**
Benzo(a)pyrene	**0.0052**
Benzo(b)fluoranthene	0.0023
Dibenzo(a,h)anthracene	**0.00069**
Indeno(1,2,3-cd)pyrene	0.0017
Naphthalene	0.261
Phenanthrene	0.0385

MW-006	
Date Sampled	8/2/2012
Benzene	**0.966**
Ethylbenzene	0.741
2-Methylnaphthalene	0.0433
Benzo(a)anthracene	**0.0045**
Benzo(a)pyrene	**0.0042**
Benzo(b)fluoranthene	0.0019
Dibenzo(a,h)anthracene	**0.00071**
Indeno(1,2,3-cd)pyrene	0.0015
Naphthalene	0.357
Phenanthrene	0.0436
Cyanide, Total	**2.6**

MW-011	
Date Sampled	8/2/2012
Benzo(a)pyrene	00002
Naphthalene	0.0374
Phenanthrene	0.0269

MW-015	
Date Sampled	8/17/2012
Benzene	0.04
2-Methylnaphthalene	0.034
Benzo(a)anthracene	**0.0105**
Benzo(a)pyrene	**0.0083**
Benzo(b)fluoranthene	0.0036
Dibenzo(a,h)anthracene	**0.0013**
Indeno(1,2,3-cd)pyrene	0.0025
Naphthalene	0.193
Phenanthrene	0.122
Cyanide, Total	0.23

BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

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Project Management Initials: Designer: NLW Checked: NC Approved: ANSI B 11" x 17"

AECOM

Figure: 7

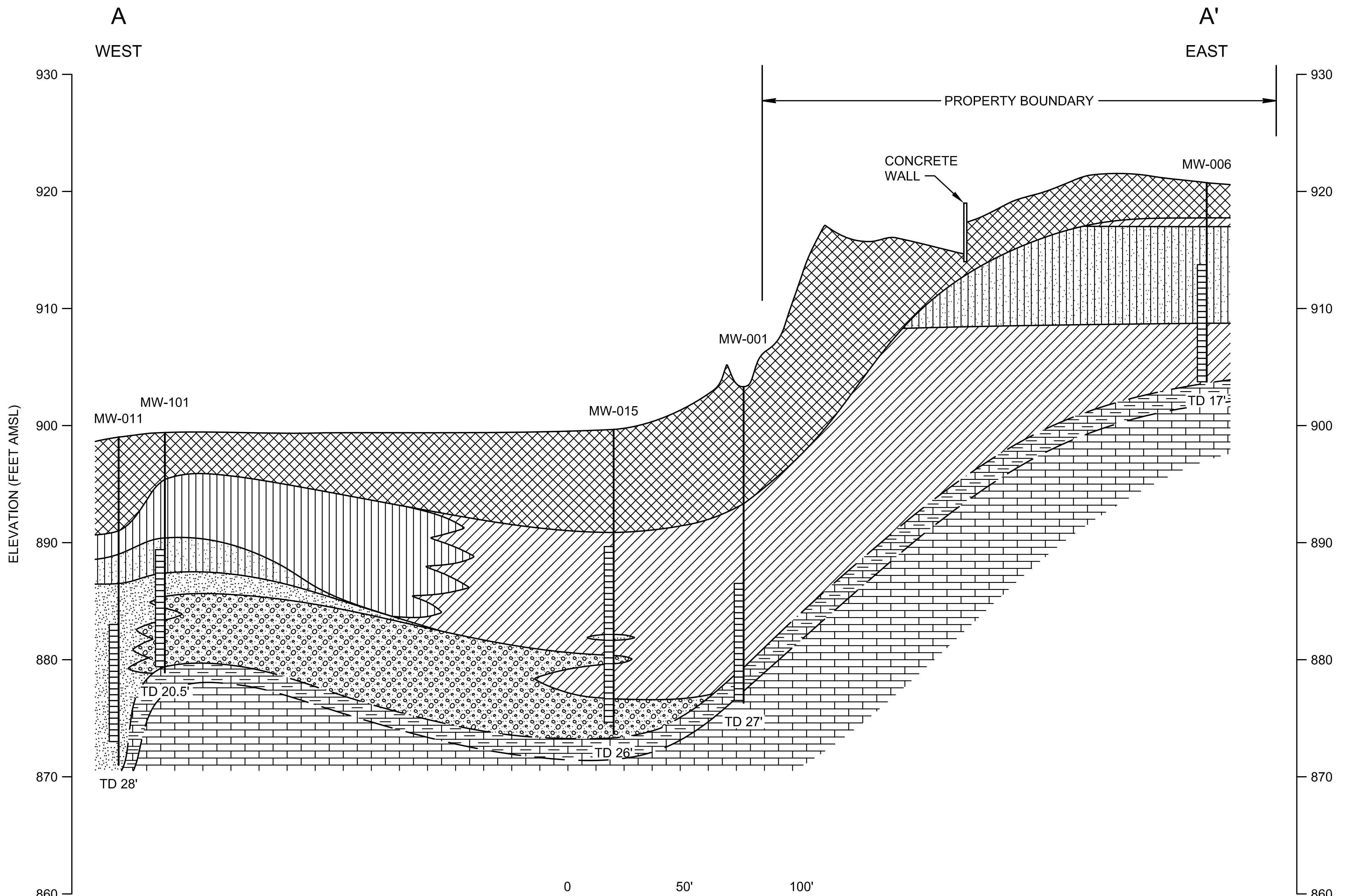
EXCEEDANCES OF RISC DCLs IN GROUNDWATER
AUGUST 2012

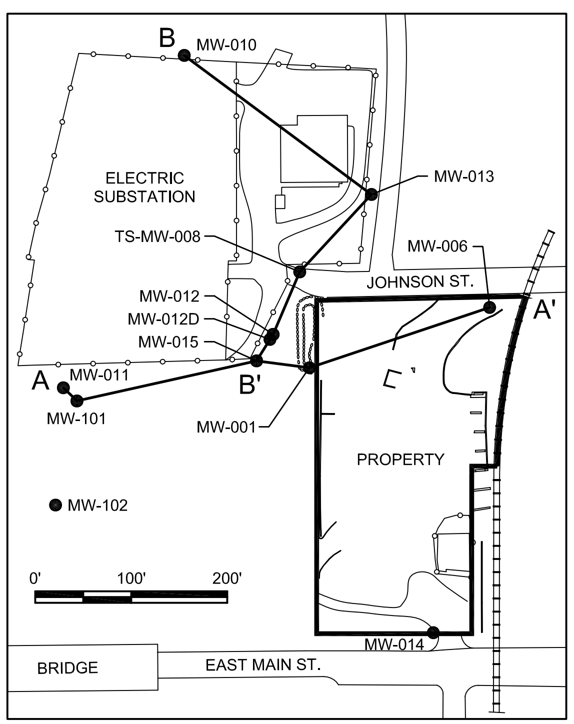
FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

LEGEND

- FILL
- CLAY AND SILTY CLAY (CL)
- CLAYEY SILT (ML)
- SILTY SAND (SM)
- SAND AND SAND WITH GRAVEL (SP, SW)
- GRAVEL, SANDY GRAVEL AND SILTY GRAVEL (GP, GW, GM)
- WEATHERED LIMESTONE AND LIME CLAY
- LIMESTONE BEDROCK
- WELL SCREEN





CROSS SECTION LOCATION KEY

0 50' 100'

HORIZONTAL SCALE: 1" = 50'

5X VERTICAL EXAGGERATION

AECOM

Figure: 8

GEOLOGIC CROSS SECTION A - A'

FORMER MGP SITE
RICHMOND, INDIANA

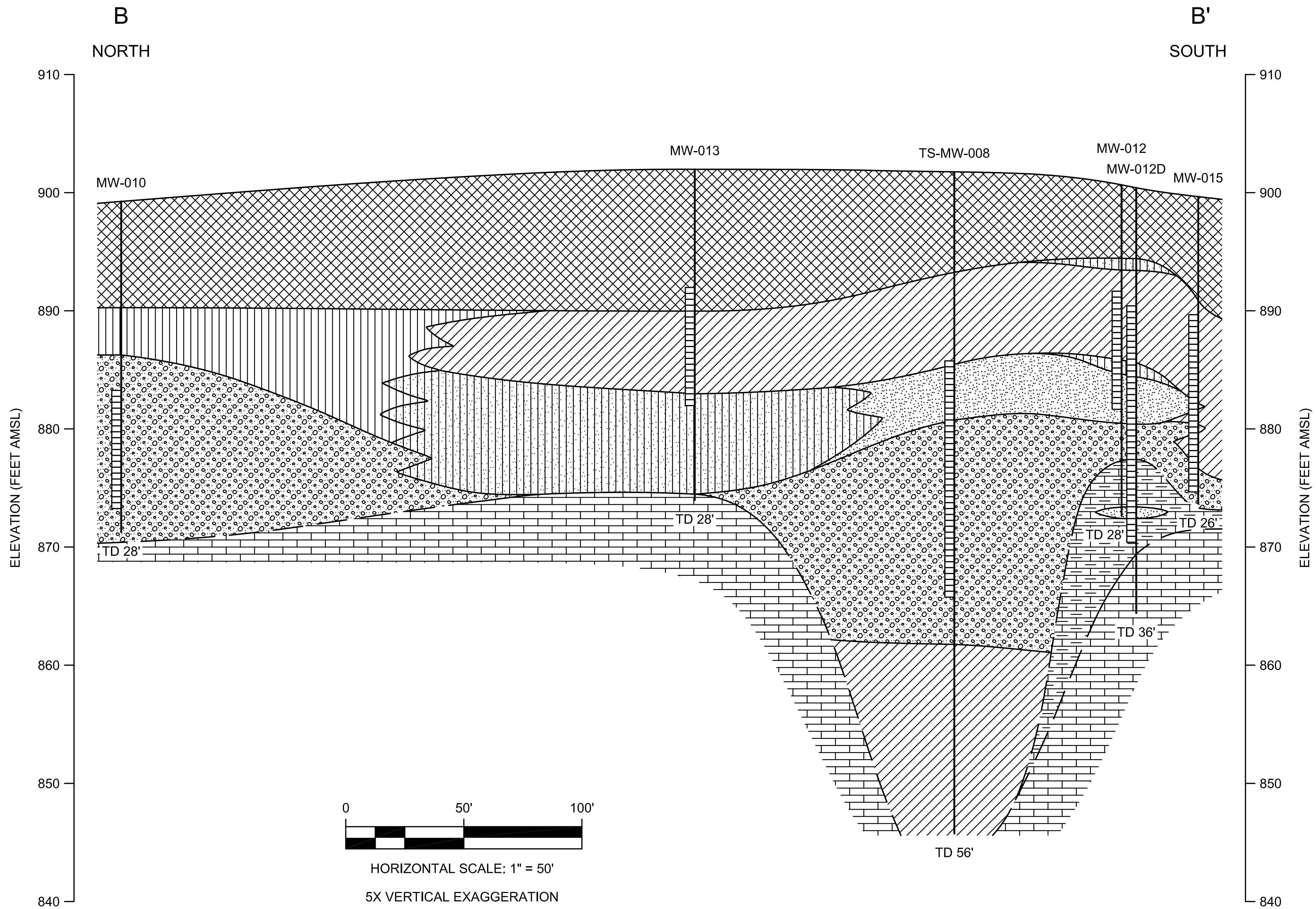
Project No.: 60194081 Date: 2012-09-25

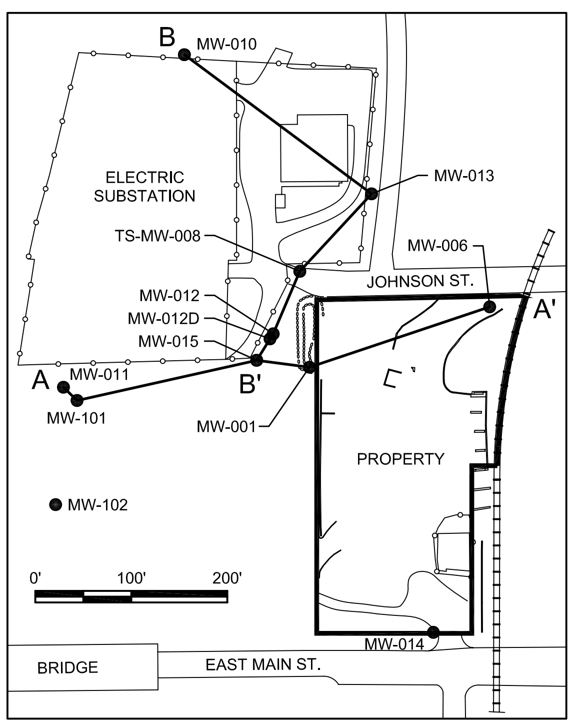
ANSI B 11" x 17" Approved:____ Checked: NC Designer: NLW Project Management Initials:

Last saved by: WILZBACHERN(2012-09-26) Last Plotted: 2012-09-26
Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG8 XSEC AA.DWG

LEGEND

- FILL
- CLAY AND SILTY CLAY (CL)
- SILT (ML)
- SILTY SAND (SM)
- SAND AND SAND WITH GRAVEL (SP, SW)
- GRAVEL, SANDY GRAVEL AND SILTY GRAVEL (GP, GW, GM)
- WEATHERED LIMESTONE AND LIME CLAY
- LIMESTONE BEDROCK
- WELL SCREEN





CROSS SECTION LOCATION KEY

AECOM

Figure: 9

GEOLOGIC CROSS SECTION B - B'

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-25

Project Management Initials: Designer: NLW Checked: NC Approved:____ ANSI B 11" x 17"

Last saved by: WILZBACHERN(2012-09-25) Last Plotted: 2012-09-25
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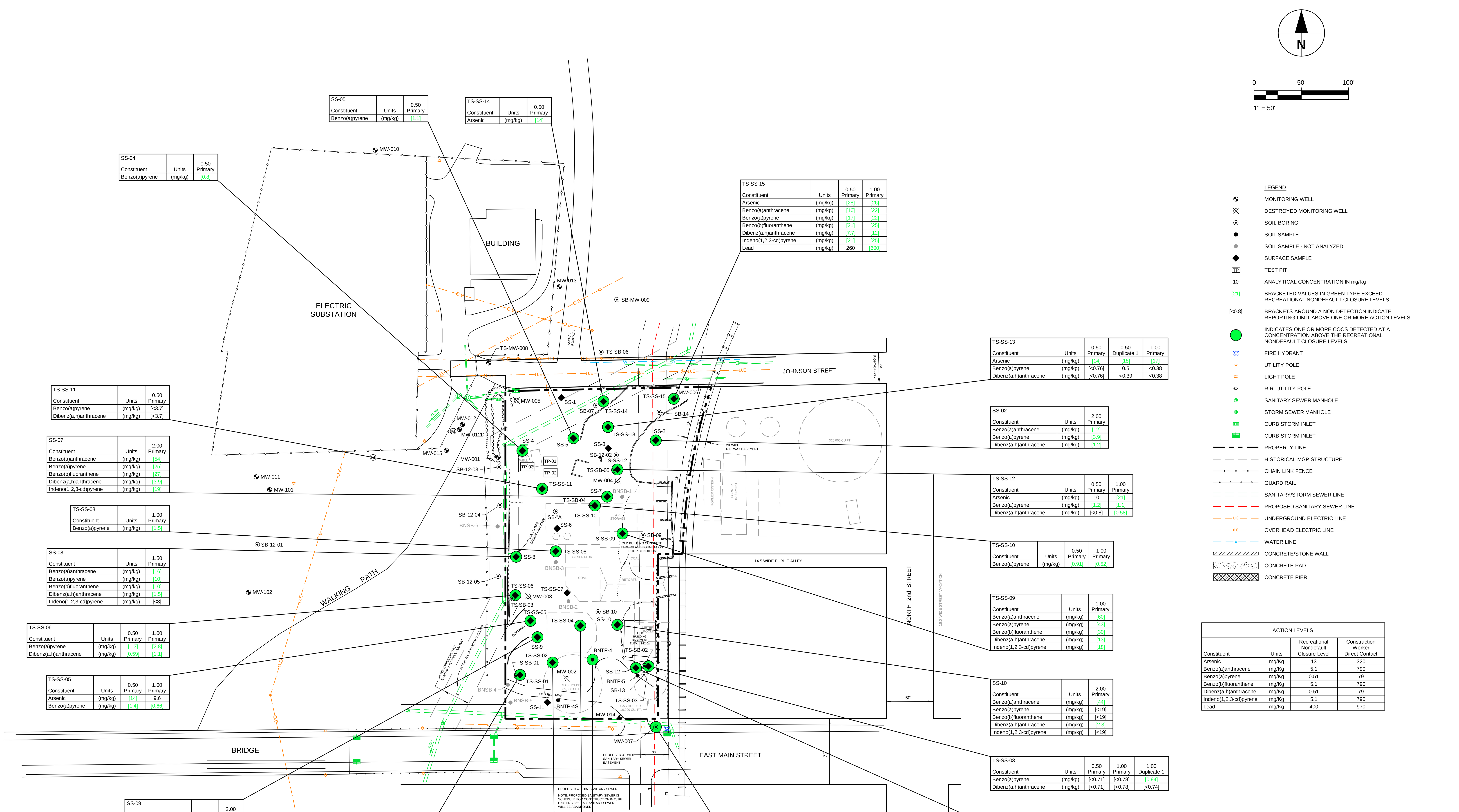


SS-05 Constituent	Units	0.50 Primary
Benzo(a)pyrene	(mg/kg)	[1.1]

TS-SS-14 Constituent	Units	0.50 Primary
Arsenic	(mg/kg)	[14]

SS-04 Constituent	Units	0.50 Primary
Benzo(a)pyrene	(mg/kg)	[0.8]

TS-SS-15 Constituent	Units	0.50 Primary	1.00 Primary
Arsenic	(mg/kg)	[28]	[26]
Benzo(a)anthracene	(mg/kg)	[16]	[22]
Benzo(a)pyrene	(mg/kg)	[17]	[22]
Benzo(b)fluoranthene	(mg/kg)	[21]	[25]
Dibenz(a,h)anthracene	(mg/kg)	[7.7]	[12]
Indeno(1,2,3-cd)pyrene	(mg/kg)	[21]	[25]
Lead	(mg/kg)	260	[600]

TS-SS-11 Constituent	Units	0.50 Primary
Benzo(a)pyrene	(mg/kg)	[<3.7]
Dibenz(a,h)anthracene	(mg/kg)	[<3.7]

SS-07 Constituent	Units	2.00 Primary
Benzo(a)anthracene	(mg/kg)	[54]
Benzo(a)pyrene	(mg/kg)	[25]
Benzo(b)fluoranthene	(mg/kg)	[27]
Dibenz(a,h)anthracene	(mg/kg)	[3.9]
Indeno(1,2,3-cd)pyrene	(mg/kg)	[19]

TS-SS-08 Constituent	Units	1.00 Primary
Benzo(a)pyrene	(mg/kg)	[1.5]

SS-08 Constituent	Units	1.50 Primary
Benzo(a)anthracene	(mg/kg)	[16]
Benzo(a)pyrene	(mg/kg)	[10]
Benzo(b)fluoranthene	(mg/kg)	[10]
Dibenz(a,h)anthracene	(mg/kg)	[1.5]
Indeno(1,2,3-cd)pyrene	(mg/kg)	[<8]

TS-SS-06 Constituent	Units	0.50 Primary	1.00 Primary
Benzo(a)pyrene	(mg/kg)	[1.3]	[2.8]
Dibenz(a,h)anthracene	(mg/kg)	[0.59]	[1.1]

TS-SS-05 Constituent	Units	0.50 Primary	1.00 Primary
Arsenic	(mg/kg)	[14]	9.6
Benzo(a)pyrene	(mg/kg)	[1.4]	[0.66]

SS-09 Constituent	Units	2.00 Primary
Benzo(a)anthracene	(mg/kg)	[6.4]
Benzo(a)pyrene	(mg/kg)	[4.1]
Dibenz(a,h)anthracene	(mg/kg)	[0.73]

TS-SS-01 Constituent	Units	0.50 Primary	1.00 Primary
Arsenic	(mg/kg)	[15]	[14]

TS-SS-02 Constituent	Units	0.50 Primary	0.50 Duplicate 1	1.00 Primary
Benzo(a)pyrene	(mg/kg)	[<0.74]	[1.1]	[1]
Dibenz(a,h)anthracene	(mg/kg)	[<0.74]	0.45	[<0.73]

BNTP-04 Constituent	Units	Primary
Benzo(a)pyrene	(mg/kg)	[1.43]

TS-SS-04 Constituent	Units	1.00 Primary
Benzo(a)pyrene	(mg/kg)	[1.2]
Dibenz(a,h)anthracene	(mg/kg)	[0.55]

MW-007 Constituent	Units	2.00 Primary
Arsenic	(mg/kg)	[22.1]

TS-SS-13 Constituent	Units	0.50 Primary	0.50 Duplicate 1	1.00 Primary
Arsenic	(mg/kg)	[14]	[18]	[17]
Benzo(a)pyrene	(mg/kg)	[<0.76]	0.5	<0.38
Dibenz(a,h)anthracene	(mg/kg)	[<0.76]	<0.39	<0.38

SS-02 Constituent	Units	2.00 Primary
Benzo(a)anthracene	(mg/kg)	[12]
Benzo(a)pyrene	(mg/kg)	[3.9]
Dibenz(a,h)anthracene	(mg/kg)	[1.2]

TS-SS-12 Constituent	Units	0.50 Primary	1.00 Primary
Arsenic	(mg/kg)	10	[21]
Benzo(a)pyrene	(mg/kg)	[1.2]	[1.1]
Dibenz(a,h)anthracene	(mg/kg)	[<0.8]	[0.58]

TS-SS-10 Constituent	Units	0.50 Primary	1.00 Primary
Benzo(a)pyrene	(mg/kg)	[0.91]	[0.52]

TS-SS-09 Constituent	Units	1.00 Primary
Benzo(a)anthracene	(mg/kg)	[60]
Benzo(a)pyrene	(mg/kg)	[43]
Benzo(b)fluoranthene	(mg/kg)	[30]
Dibenz(a,h)anthracene	(mg/kg)	[13]
Indeno(1,2,3-cd)pyrene	(mg/kg)	[18]

SS-10 Constituent	Units	2.00 Primary
Benzo(a)anthracene	(mg/kg)	[44]
Benzo(a)pyrene	(mg/kg)	[<19]
Benzo(b)fluoranthene	(mg/kg)	[<19]
Dibenz(a,h)anthracene	(mg/kg)	[2.3]
Indeno(1,2,3-cd)pyrene	(mg/kg)	[<19]

TS-SS-03 Constituent	Units	0.50 Primary	1.00 Primary	1.00 Duplicate 1
Benzo(a)pyrene	(mg/kg)	[<0.71]	[<0.78]	[0.94]
Dibenz(a,h)anthracene	(mg/kg)	[<0.71]	[<0.78]	[<0.74]

SS-12 Constituent	Units	1.50 Primary
Benzo(a)pyrene	(mg/kg)	[1.4]

LEGEND

- MONITORING WELL
- DESTROYED MONITORING WELL
- SOIL BORING
- SOIL SAMPLE
- SOIL SAMPLE - NOT ANALYZED
- SURFACE SAMPLE
- TP — TEST PIT
- 10 — ANALYTICAL CONCENTRATION IN mg/Kg
- [21] — BRACKETED VALUES IN GREEN TYPE EXCEED RECREATIONAL NONDEFAULT CLOSURE LEVELS
- [<0.8] — BRACKETS AROUND A NON DETECTION INDICATE REPORTING LIMIT ABOVE ONE OR MORE ACTION LEVELS
- INDICATES ONE OR MORE COCS DETECTED AT A CONCENTRATION ABOVE THE RECREATIONAL NONDEFAULT CLOSURE LEVELS
- FIRE HYDRANT
- UTILITY POLE
- LIGHT POLE
- R.R. UTILITY POLE
- SANITARY SEWER MANHOLE
- STORM SEWER MANHOLE
- CURB STORM INLET
- CURB STORM INLET
- PROPERTY LINE
- HISTORICAL MGP STRUCTURE
- CHAIN LINK FENCE
- GUARD RAIL
- SANITARY/STORM SEWER LINE
- PROPOSED SANITARY SEWER LINE
- UNDERGROUND ELECTRIC LINE
- OVERHEAD ELECTRIC LINE
- WATER LINE
- CONCRETE/STONE WALL
- CONCRETE PAD
- CONCRETE PIER

ACTION LEVELS

Constituent	Units	Recreational Nondefault Closure Level	Construction Worker Direct Contact
Arsenic	mg/Kg	13	320
Benzo(a)anthracene	mg/Kg	5.1	790
Benzo(a)pyrene	mg/Kg	0.51	79
Benzo(b)fluoranthene	mg/Kg	5.1	790
Dibenz(a,h)anthracene	mg/Kg	0.51	79
Indeno(1,2,3-cd)pyrene	mg/Kg	5.1	790
Lead	mg/Kg	400	970

BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

AECOM

Figure: 10

SURFACE SOIL EXCEEDANCE MAP
PRE 2012 INVESTIGATION DATA

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

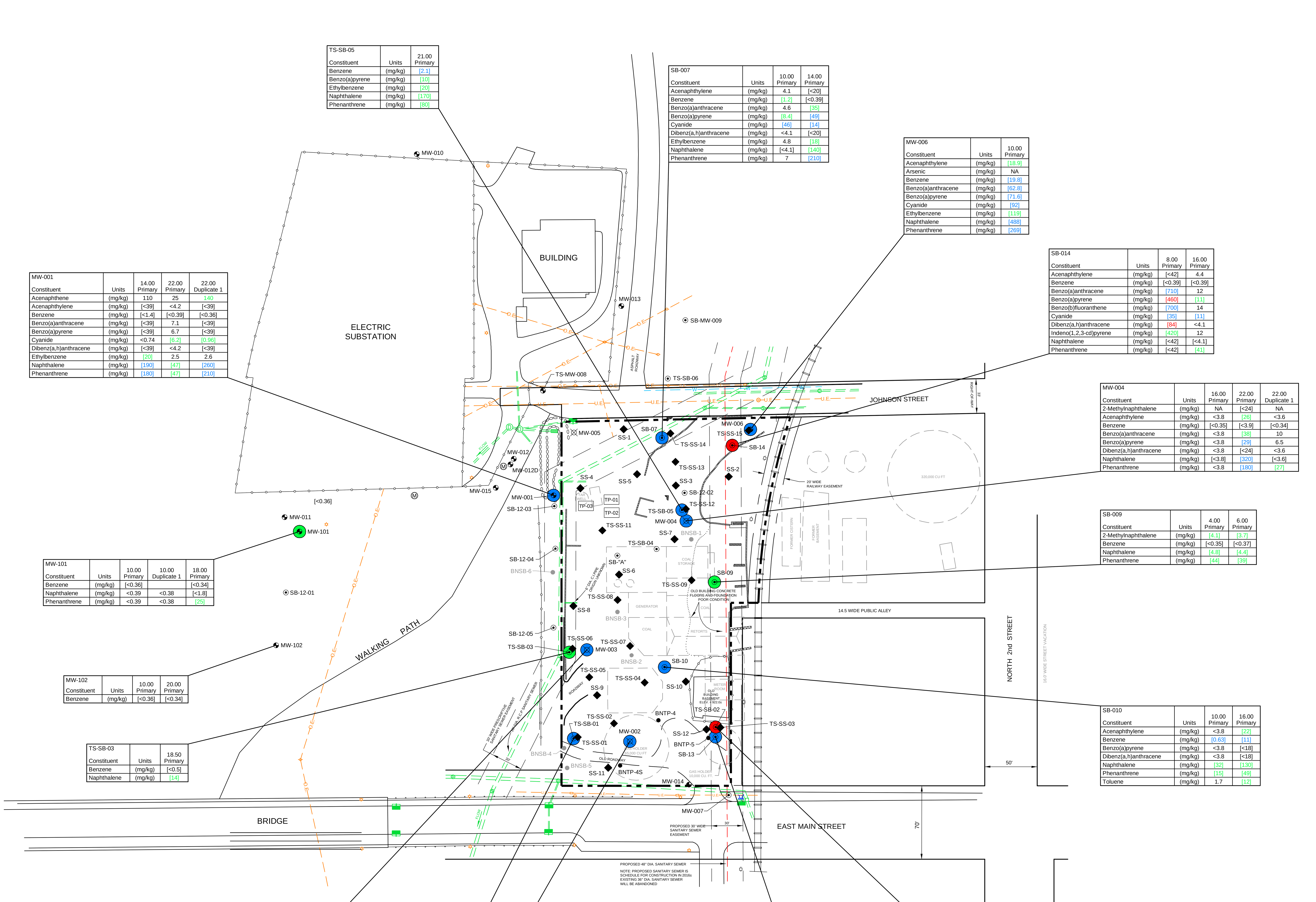
ANSI D 22" x 34" Approved: Checked: NC Designer: NLW Project Management Initials:

Last saved by: WILZBACHERN(2012-09-27) Last Plotted: 2012-09-27
Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG10 SURFACE SOIL EXCEEDANCES.DWG

SUBSURFACE SOIL EXCEEDANCE MAP
PRE 2012 INVESTIGATION DATA

AECOM

Figure: 11



TS-SB-05 Constituent	Units	21.00 Primary
Benzene	(mg/kg)	[2.1]
Benzo(a)pyrene	(mg/kg)	[10]
Ethylbenzene	(mg/kg)	[20]
Naphthalene	(mg/kg)	[170]
Phenanthrene	(mg/kg)	[80]

SB-007 Constituent	Units	10.00 Primary	14.00 Primary
Acenaphthylene	(mg/kg)	4.1	[<20]
Benzene	(mg/kg)	[1.2]	[<0.39]
Benzo(a)anthracene	(mg/kg)	4.6	[35]
Benzo(a)pyrene	(mg/kg)	[8.4]	[49]
Cyanide	(mg/kg)	[46]	[14]
Dibenz(a,h)anthracene	(mg/kg)	<4.1	[<20]
Ethylbenzene	(mg/kg)	4.8	[18]
Naphthalene	(mg/kg)	[<4.1]	[140]
Phenanthrene	(mg/kg)	7	[210]

MW-006 Constituent	Units	10.00 Primary
Acenaphthylene	(mg/kg)	[18.9]
Arsenic	(mg/kg)	NA
Benzene	(mg/kg)	[19.8]
Benzo(a)anthracene	(mg/kg)	[62.8]
Benzo(a)pyrene	(mg/kg)	[71.6]
Cyanide	(mg/kg)	[92]
Ethylbenzene	(mg/kg)	[119]
Naphthalene	(mg/kg)	[488]
Phenanthrene	(mg/kg)	[269]

MW-001 Constituent	Units	14.00 Primary	22.00 Primary	22.00 Duplicate 1
Acenaphthene	(mg/kg)	110	25	140
Acenaphthylene	(mg/kg)	[<39]	<4.2	[<39]
Benzene	(mg/kg)	[<1.4]	[<0.39]	[<0.36]
Benzo(a)anthracene	(mg/kg)	[<39]	7.1	[<39]
Benzo(a)pyrene	(mg/kg)	[<39]	6.7	[<39]
Cyanide	(mg/kg)	<0.74	[6.2]	[0.96]
Dibenz(a,h)anthracene	(mg/kg)	[<39]	<4.2	[<39]
Ethylbenzene	(mg/kg)	[20]	2.5	2.6
Naphthalene	(mg/kg)	[190]	[47]	[260]
Phenanthrene	(mg/kg)	[180]	[47]	[210]

SB-014 Constituent	Units	8.00 Primary	16.00 Primary
Acenaphthylene	(mg/kg)	[<42]	4.4
Benzene	(mg/kg)	[<0.39]	[<0.39]
Benzo(a)anthracene	(mg/kg)	[710]	12
Benzo(a)pyrene	(mg/kg)	[460]	[11]
Benzo(b)fluoranthene	(mg/kg)	[700]	14
Cyanide	(mg/kg)	[35]	[11]
Dibenz(a,h)anthracene	(mg/kg)	[84]	<4.1
Indeno(1,2,3-cd)pyrene	(mg/kg)	[420]	12
Naphthalene	(mg/kg)	[<42]	[<4.1]
Phenanthrene	(mg/kg)	[<42]	[41]

MW-004 Constituent	Units	16.00 Primary	22.00 Primary	22.00 Duplicate 1
2-Methylnaphthalene	(mg/kg)	NA	[<24]	NA
Acenaphthylene	(mg/kg)	<3.8	[26]	<3.6
Benzene	(mg/kg)	[<0.35]	[<3.9]	[<0.34]
Benzo(a)anthracene	(mg/kg)	<3.8	[38]	10
Benzo(a)pyrene	(mg/kg)	<3.8	[29]	6.5
Dibenz(a,h)anthracene	(mg/kg)	<3.8	[<24]	<3.6
Naphthalene	(mg/kg)	[<3.8]	[320]	[<3.6]
Phenanthrene	(mg/kg)	<3.8	[180]	[27]

SB-009 Constituent	Units	4.00 Primary	6.00 Primary
2-Methylnaphthalene	(mg/kg)	[4.1]	[3.7]
Benzene	(mg/kg)	[<0.35]	[<0.37]
Naphthalene	(mg/kg)	[4.8]	[4.4]
Phenanthrene	(mg/kg)	[44]	[39]

MW-101 Constituent	Units	10.00 Primary	10.00 Duplicate 1	18.00 Primary
Benzene	(mg/kg)	[<0.36]		[<0.34]
Naphthalene	(mg/kg)	<0.39	<0.38	[<1.8]
Phenanthrene	(mg/kg)	<0.39	<0.38	[25]

MW-102 Constituent	Units	10.00 Primary	20.00 Primary
Benzene	(mg/kg)	[<0.36]	[<0.34]

TS-SB-03 Constituent	Units	18.50 Primary
Benzene	(mg/kg)	[<0.5]
Naphthalene	(mg/kg)	[14]

SB-010 Constituent	Units	10.00 Primary	16.00 Primary
Acenaphthylene	(mg/kg)	<3.8	[22]
Benzene	(mg/kg)	[0.63]	[11]
Benzo(a)pyrene	(mg/kg)	<3.8	[<18]
Dibenz(a,h)anthracene	(mg/kg)	<3.8	[<18]
Naphthalene	(mg/kg)	[32]	[130]
Phenanthrene	(mg/kg)	[15]	[49]
Toluene	(mg/kg)	1.7	[12]

MW-003 Constituent	Units	10.00 Primary	16.00 Primary
Benzene	(mg/kg)	[0.39]	[<1.6]
Benzo(a)anthracene	(mg/kg)	3.2	[41]
Benzo(a)pyrene	(mg/kg)	2.9	[29]
Cyanide	(mg/kg)	0.59	[18]
Naphthalene	(mg/kg)	[<0.82]	[220]
Phenanthrene	(mg/kg)	<0.82	[180]

TS-SB-01 Constituent	Units	18.00 Primary
Arsenic	(mg/kg)	[6.1]
Benzene	(mg/kg)	[72]
Ethylbenzene	(mg/kg)	[160]
Naphthalene	(mg/kg)	[44]
Phenanthrene	(mg/kg)	[18]
Toluene	(mg/kg)	[22]

MW-002 Constituent	Units	4.00 Primary	14.00 Primary
Acenaphthylene	(mg/kg)	<3.7	[<19]
Benzene	(mg/kg)	[<0.34]	[2.3]
Benzo(a)anthracene	(mg/kg)	<3.7	[<19]
Benzo(a)pyrene	(mg/kg)	<3.7	[<19]
Dibenz(a,h)anthracene	(mg/kg)	<3.7	[<19]
Naphthalene	(mg/kg)	[<3.7]	[210]
Phenanthrene	(mg/kg)	<3.7	[120]

SB-013 Constituent	Units	22.00 Primary
Acenaphthylene	(mg/kg)	[220]
Benzene	(mg/kg)	[14]
Benzo(a)anthracene	(mg/kg)	[120]
Benzo(a)pyrene	(mg/kg)	[<96]
Benzo(b)fluoranthene	(mg/kg)	[<96]
Dibenz(a,h)anthracene	(mg/kg)	[<96]
Fluorene	(mg/kg)	[280]
Naphthalene	(mg/kg)	[1100]
Phenanthrene	(mg/kg)	[540]
Toluene	(mg/kg)	[26]

TS-SB-02 Constituent	Units	18.00 Primary	18.00 Duplicate 1
Arsenic	(mg/kg)	[8.8]	[15]
Benzene	(mg/kg)	[1.6]	[7.9]
Benzo(a)anthracene	(mg/kg)	[23]	[46]
Benzo(a)pyrene	(mg/kg)	[19]	[42]
Ethylbenzene	(mg/kg)	13	[160]
Lead	(mg/kg)	[580]	[1500]
Naphthalene	(mg/kg)	[46]	[160]
Phenanthrene	(mg/kg)	[86]	[210]

LEGEND

- MONITORING WELL
- SOIL BORING
- SOIL SAMPLE
- SOIL SAMPLE - NOT ANALYZED
- SURFACE SAMPLE
- TP — TEST PIT
- 12 — ANALYTICAL CONCENTRATION IN mg/Kg
- [11] — BRACKETED VALUES IN GREEN TYPE EXCEED RESIDENTIAL MIGRATION TO GROUND WATER CRITERIA
- [35] — BRACKETED VALUES IN BLUE TYPE EXCEED INDUSTRIAL MIGRATION TO GROUND WATER CRITERIA
- [84] — BRACKETED VALUES IN RED TYPE EXCEED CONSTRUCTION WORKER DIRECT CONTACT CRITERIA
- [<42] — BRACKETS AROUND A NON DETECTION INDICATE REPORTING LIMIT ABOVE ONE OR MORE ACTION LEVELS
- NA — NOT ANALYZED
- INDICATES ONE OR MORE COCS DETECTED AT A CONCENTRATION ABOVE THE RESIDENTIAL MIGRATION TO GROUND WATER CRITERIA
- INDICATES ONE OR MORE COCS DETECTED AT A CONCENTRATION ABOVE BOTH THE RESIDENTIAL AND INDUSTRIAL MIGRATION TO GROUND WATER CRITERIA
- INDICATES ONE OR MORE COCS DETECTED AT A CONCENTRATION ABOVE BOTH THE RESIDENTIAL AND INDUSTRIAL MIGRATION TO GROUND WATER CRITERIA AND THE CONSTRUCTION WORKER DIRECT CONTACT CRITERIA
- FIRE HYDRANT
- UTILITY POLE
- LIGHT POLE
- R.R. UTILITY POLE
- SANITARY SEWER MANHOLE
- STORM SEWER MANHOLE
- CURB STORM INLET
- CURB STORM INLET
- PROPERTY LINE
- HISTORICAL MGP STRUCTURE
- CHAIN LINK FENCE
- GUARD RAIL
- SANITARY/STORM SEWER LINE
- PROPOSED SANITARY SEWER LINE
- UNDERGROUND ELECTRIC LINE
- OVERHEAD ELECTRIC LINE
- WATER LINE
- CONCRETE/STONE WALL
- CONCRETE PAD
- CONCRETE PIER

ACTION LEVELS				
Constituent	Units	Residential Migration to Ground Water	Industrial Migration to Ground Water	Construction Worker Direct Contact
2-Methylnaphthalene	mg/Kg	3.1	42	3,300
Acenaphthene	mg/Kg	130	1,800	50,000
Acenaphthylene	mg/Kg	18	180	5,900
Arsenic	mg/Kg	5.8	5.8	320
Benzene	mg/Kg	0.034	0.35	560
Benzo(a)anthracene	mg/Kg	19	62	790
Benzo(a)pyrene	mg/Kg	8.2	16	79
Cyanide	mg/Kg	0.94	9.6	23,000
Dibenz(a,h)anthracene	mg/Kg	18	60	79
Ethylbenzene	mg/Kg	13	200	29,000
Fluorene	mg/Kg	170	2,300	33,000
Indeno(1,2,3-cd)pyrene	mg/Kg	160	540	790
Lead	mg/Kg	81	230	970
Naphthalene	mg/Kg	0.7	170	17,000
Phenanthrene	mg/Kg	13	170	2,500
Toluene	mg/Kg	12	96	49,000

BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

Project Management Initials: Designer: NLW Checked: NC Approved: ANSI D 22" x 34"

Last saved by: WILZBACHERN(2012-09-27) Last Plotted: 2012-09-27
Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG11 SUBSURFACE SOIL EXCEEDANCES.DWG

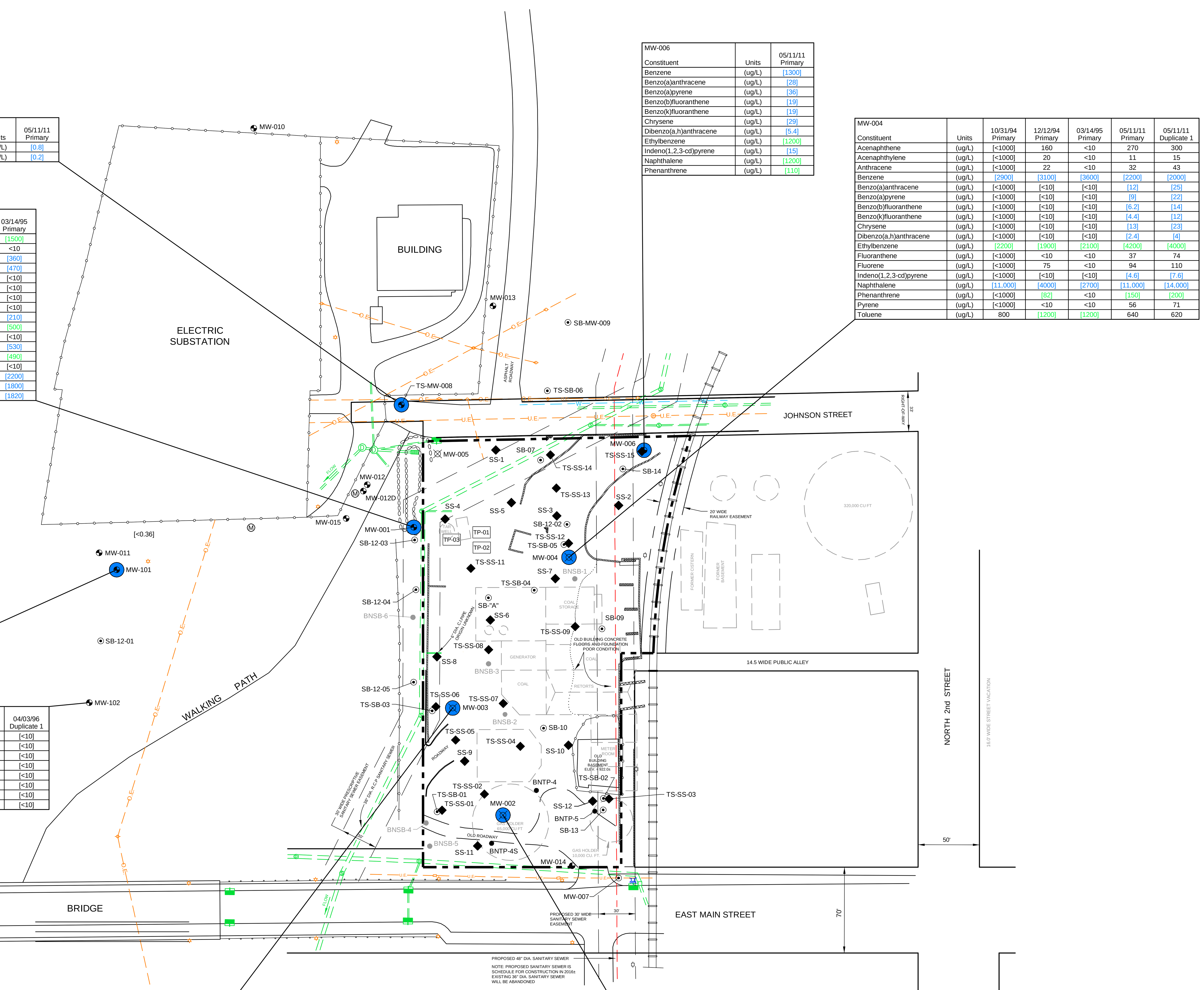
GROUNDWATER EXCEEDANCE MAP
PRE 2012 INVESTIGATION DATA

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

AECOM

Figure: 12



MW-008 Constituent	Units	05/11/11 Primary
Benzo(a)pyrene	(ug/L)	[0.8]
Indeno(1,2,3-cd)pyrene	(ug/L)	[0.2]

MW-001 Constituent	Units	10/31/94 Primary	12/12/94 Primary	03/14/95 Primary
Acenaphthene	(ug/L)	[730]	[2200]	[1500]
Acenaphthylene	(ug/L)	[<400]	<10	<10
Anthracene	(ug/L)	[<400]	[830]	[360]
Benzene	(ug/L)	[480]	[480]	[470]
Benzo(a)anthracene	(ug/L)	[<400]	[<10]	[<10]
Benzo(a)pyrene	(ug/L)	[<400]	[<10]	[<10]
Benzo(b)fluoranthene	(ug/L)	[<400]	[<10]	[<10]
Benzo(k)fluoranthene	(ug/L)	[<400]	[<10]	[<10]
Chrysene	(ug/L)	[<400]	[<10]	[210]
Cyanide	(ug/L)	[410]	[470]	[500]
Dibenzo(a,h)anthracene	(ug/L)	[<400]	[<10]	[<10]
Fluoranthene	(ug/L)	[<400]	[1100]	[530]
Fluorene	(ug/L)	[<400]	[1000]	[490]
Indeno(1,2,3-cd)pyrene	(ug/L)	[<400]	[<10]	[<10]
Naphthalene	(ug/L)	[4900]	[4600]	[2200]
Phenanthrene	(ug/L)	[630]	[2900]	[1800]
Pyrene	(ug/L)	[<400]	[1700]	[1820]

MW-101 Constituent	Units	10/17/95 Primary	12/21/95 Primary	12/21/95 Duplicate 1
Acenaphthene	(ug/L)	[601]	[1100]	330
Acenaphthylene	(ug/L)	[<100]	[130]	38
Anthracene	(ug/L)	[190]	[430]	[100]
Benzo(a)anthracene	(ug/L)	[110]	[280]	[63]
Benzo(a)pyrene	(ug/L)	[<100]	[260]	[<10]
Benzo(b)fluoranthene	(ug/L)	[<100]	[190]	[35]
Benzo(k)fluoranthene	(ug/L)	[<100]	[<100]	[12]
Chrysene	(ug/L)	[110]	[220]	[56]
Dibenzo(a,h)anthracene	(ug/L)	[<100]	[<100]	[<10]
Fluoranthene	(ug/L)	[260]	[680]	130
Fluorene	(ug/L)	220	[530]	130
Indeno(1,2,3-cd)pyrene	(ug/L)	[160]	[<100]	[19]
Naphthalene	(ug/L)	[<100]	[<100]	[<10]
Phenanthrene	(ug/L)	[700]	[1400]	[330]
Pyrene	(ug/L)	[360]	[820]	[170]

MW-102 Constituent	Units	10/17/95 Primary	10/17/95 Duplicate 1	12/21/95 Primary	04/03/96 Primary	04/03/96 Duplicate 1
Benzo(a)anthracene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Benzo(a)pyrene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Benzo(b)fluoranthene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Benzo(k)fluoranthene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Chrysene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Dibenzo(a,h)anthracene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Indeno(1,2,3-cd)pyrene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]
Naphthalene	(ug/L)	[<10]	[<10]	[<10]	[<10]	[<10]

MW-006 Constituent	Units	05/11/11 Primary
Benzene	(ug/L)	[1300]
Benzo(a)anthracene	(ug/L)	[28]
Benzo(a)pyrene	(ug/L)	[36]
Benzo(b)fluoranthene	(ug/L)	[19]
Benzo(k)fluoranthene	(ug/L)	[19]
Chrysene	(ug/L)	[29]
Dibenzo(a,h)anthracene	(ug/L)	[5.4]
Ethylbenzene	(ug/L)	[1200]
Indeno(1,2,3-cd)pyrene	(ug/L)	[15]
Naphthalene	(ug/L)	[1200]
Phenanthrene	(ug/L)	[110]

MW-004 Constituent	Units	10/31/94 Primary	12/12/94 Primary	03/14/95 Primary	05/11/11 Primary	05/11/11 Duplicate 1
Acenaphthene	(ug/L)	[<1000]	160	<10	270	300
Acenaphthylene	(ug/L)	[<1000]	20	<10	11	15
Anthracene	(ug/L)	[<1000]	22	<10	32	43
Benzene	(ug/L)	[2900]	[3100]	[3600]	[2200]	[2000]
Benzo(a)anthracene	(ug/L)	[<1000]	[<10]	[<10]	[12]	[25]
Benzo(a)pyrene	(ug/L)	[<1000]	[<10]	[<10]	[9]	[22]
Benzo(b)fluoranthene	(ug/L)	[<1000]	[<10]	[<10]	[6.2]	[14]
Benzo(k)fluoranthene	(ug/L)	[<1000]	[<10]	[<10]	[4.4]	[12]
Chrysene	(ug/L)	[<1000]	[<10]	[<10]	[13]	[23]
Dibenzo(a,h)anthracene	(ug/L)	[<1000]	[<10]	[<10]	[2.4]	[4]
Ethylbenzene	(ug/L)	[2200]	[1900]	[2100]	[4200]	[4000]
Fluoranthene	(ug/L)	[<1000]	<10	<10	37	74
Fluorene	(ug/L)	[<1000]	75	<10	94	110
Indeno(1,2,3-cd)pyrene	(ug/L)	[<1000]	[<10]	[<10]	[4.6]	[7.6]
Naphthalene	(ug/L)	[11,000]	[4000]	[2700]	[11,000]	[14,000]
Phenanthrene	(ug/L)	[<1000]	[82]	<10	[150]	[200]
Pyrene	(ug/L)	[<1000]	<10	<10	56	71
Toluene	(ug/L)	800	[1200]	[1200]	640	620

MW-003 Constituent	Units	10/31/94 Primary	12/12/94 Primary	03/14/95 Primary	05/11/11 Primary
Acenaphthene	(ug/L)	[470]	370	<10	51
Acenaphthylene	(ug/L)	[<200]	65	<10	2.4
Anthracene	(ug/L)	[280]	[240]	40	3.6
Benzene	(ug/L)	[82]	<5	<5	<5
Benzo(a)anthracene	(ug/L)	[<200]	[190]	[<10]	0.63
Benzo(a)pyrene	(ug/L)	[<200]	[71]	[<10]	[0.52]
Benzo(b)fluoranthene	(ug/L)	[<200]	[72]	[<10]	0.41
Benzo(k)fluoranthene	(ug/L)	[<200]	[<10]	[<10]	0.27
Chrysene	(ug/L)	[<200]	[150]	[<10]	0.54
Cyanide	(ug/L)	[250]	190	170	NA
Dibenzo(a,h)anthracene	(ug/L)	[<200]	[<10]	[<10]	<0.1
Fluoranthene	(ug/L)	[360]	[300]	62	3.8
Fluorene	(ug/L)	[340]	[320]	81	24
Indeno(1,2,3-cd)pyrene	(ug/L)	[<200]	[<10]	[<10]	[0.11]
Naphthalene	(ug/L)	[1800]	[450]	[140]	4.9
Phenanthrene	(ug/L)	[880]	[670]	[210]	[34]
Pyrene	(ug/L)	[440]	[470]	78	2.6

MW-002 Constituent	Units	10/31/94 Primary	10/31/24 Duplicate 1	12/12/94 Primary	12/12/94 Duplicate 1	03/14/95 Primary	03/14/95 Duplicate 1	05/11/11 Primary
Acenaphthylene	(ug/L)	[<200]	[<200]	<10	<10	<10	41	6.2
Anthracene	(ug/L)	[<200]	[<200]	<10	<10	<10	<10	0.37
Arsenic	(ug/L)	NA	NA	NA	NA	NA	NA	[12]
Benzene	(ug/L)	[6100]	[5900]	[5100]	[5100]	[7200]	[6500]	[1400]
Benzo(a)anthracene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	<0.1
Benzo(a)pyrene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	<0.1
Benzo(b)fluoranthene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	0.17
Benzo(k)fluoranthene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	<0.1
Chrysene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	<0.1
Cyanide	(ug/L)	[330]	<10	[330]	[390]	[310]	[310]	NA
Dibenzo(a,h)anthracene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	<0.1
Ethylbenzene	(ug/L)	310	320	[1700]	<5	<5	<5	140
Indeno(1,2,3-cd)pyrene	(ug/L)	[<200]	[<200]	[<10]	[<10]	[<10]	[<10]	<0.02
Naphthalene	(ug/L)	[1700]	[1700]	[2200]	[1900]	[580]	[450]	[400]
Phenanthrene	(ug/L)	[<200]	[<200]	<10	<10	<10	[47]	1
Pyrene	(ug/L)	[<200]	[<200]	<10	<10	<10	<10	0.3
Toluene	(ug/L)	[1800]	[1800]	<5	[1400]	[2700]	[2200]	530

LEGEND

- MONITORING WELL
- SOIL BORING
- SOIL SAMPLE
- SOIL SAMPLE - NOT ANALYZED
- SURFACE SAMPLE
- TP TEST PIT
- 74 ANALYTICAL CONCENTRATION IN ug/L
- [150] BRACKETED VALUES IN GREEN TYPE EXCEED RESIDENTIAL DEFAULT CLOSURE LEVELS
- [25] BRACKETED VALUES IN BLUE TYPE EXCEED INDUSTRIAL DEFAULT CLOSURE LEVELS
- [<10] BRACKETS AROUND A NON DETECTION INDICATE REPORTING LIMIT ABOVE ONE OR MORE ACTION LEVELS
- INDICATES ONE OR MORE COCS DETECTED AT A CONCENTRATION ABOVE BOTH THE RESIDENTIAL AND INDUSTRIAL DEFAULT CLOSURE LEVELS
- FIRE HYDRANT
- UTILITY POLE
- LIGHT POLE
- R.R. UTILITY POLE
- SANITARY SEWER MANHOLE
- STORM SEWER MANHOLE
- CURB STORM INLET
- CURB STORM INLET
- PROPERTY LINE
- HISTORICAL MGP STRUCTURE
- CHAIN LINK FENCE
- GUARD RAIL
- SANITARY/STORM SEWER LINE
- PROPOSED SANITARY SEWER LINE
- U.E. UNDERGROUND ELECTRIC LINE
- O.E. OVERHEAD ELECTRIC LINE
- W WATER LINE
- CONCRETE/STONE WALL
- CONCRETE PAD
- CONCRETE PIER

ACTION LEVELS			
Constituent	Units	Residential Default Closure Level	Industrial Default Closure Level
Acenaphthene	ug/L	460	4,200
Acenaphthylene	ug/L	71	730
Anthracene	ug/L	43	43
Arsenic	ug/L	10	10
Benzene	ug/L	5	52
Benzo(a)anthracene	ug/L	1.2	3.9
Benzo(a)pyrene	ug/L	0.2	0.39
Benzo(b)fluoranthene	ug/L	1.2	1.5
Benzo(k)fluoranthene	ug/L	0.8	0.8
Chrysene	ug/L	1.6	1.6
Cyanide	ug/L	200	2,000
Dibenzo(a,h)anthracene	ug/L	0.12	0.39
Ethylbenzene	ug/L	700	10,000
Fluoranthene	ug/L	210	210
Fluorene	ug/L	310	2,000
Indeno(1,2,3-cd)pyrene	ug/L	0.022	0.022
Naphthalene	ug/L	8.3	2,000
Phenanthrene	ug/L	23	310
Pyrene	ug/L	140	140
Toluene	ug/L	1,000	8,200

BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

ANSI D 22" x 34" Approved: ____ Checked: NC Designer: NLW Project Management Initials: ____

Last saved by: WILZBACHERN(2012-09-24) Last Plotted: 2012-09-27
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ANSI B 11" x 17"
Approved:____
Checked: NC
Designer: NLW
Project Management Initials:
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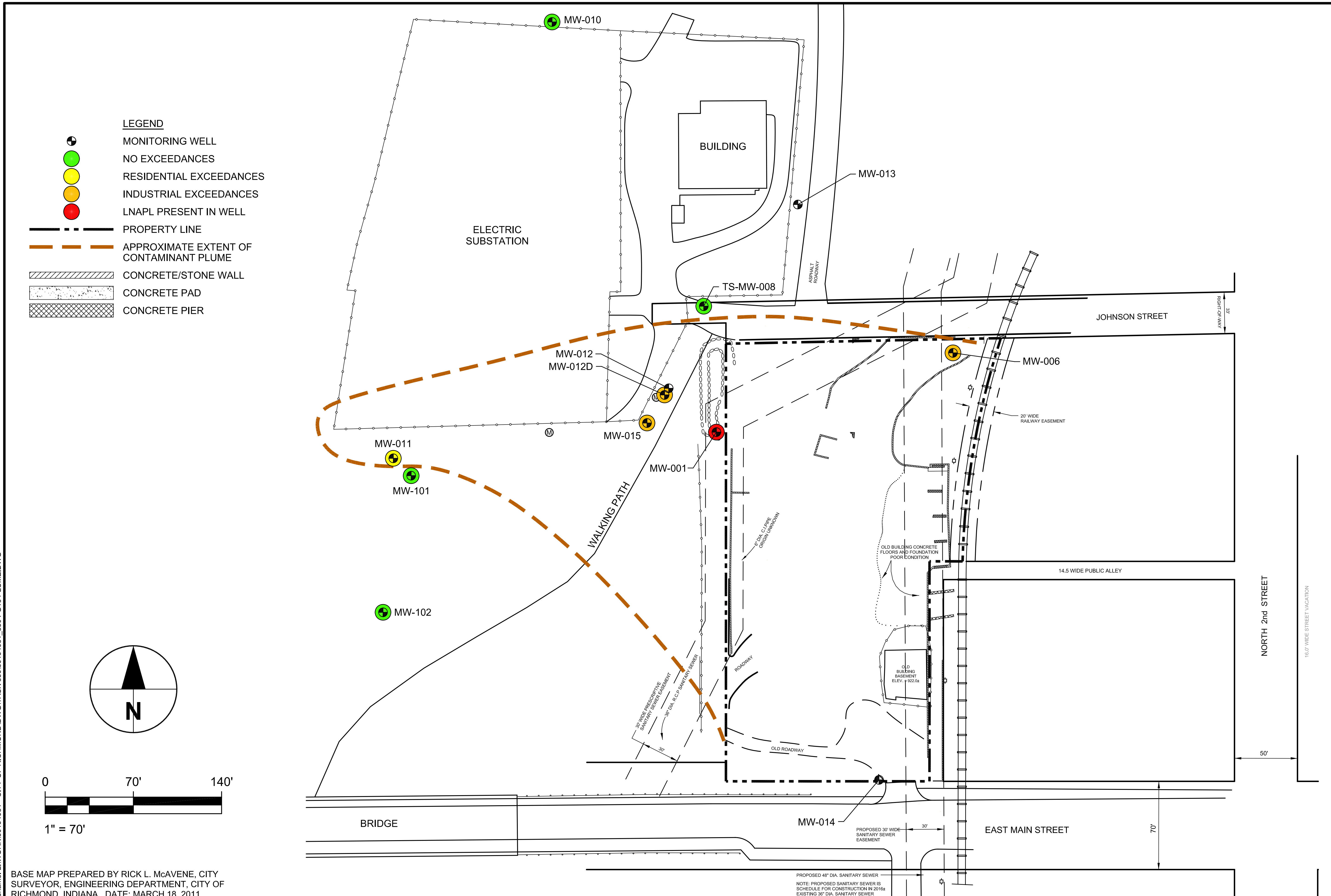

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Figure: 13

APPROXIMATE EXTENT OF GROUNDWATER PLUME
AUGUST 2012

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-27

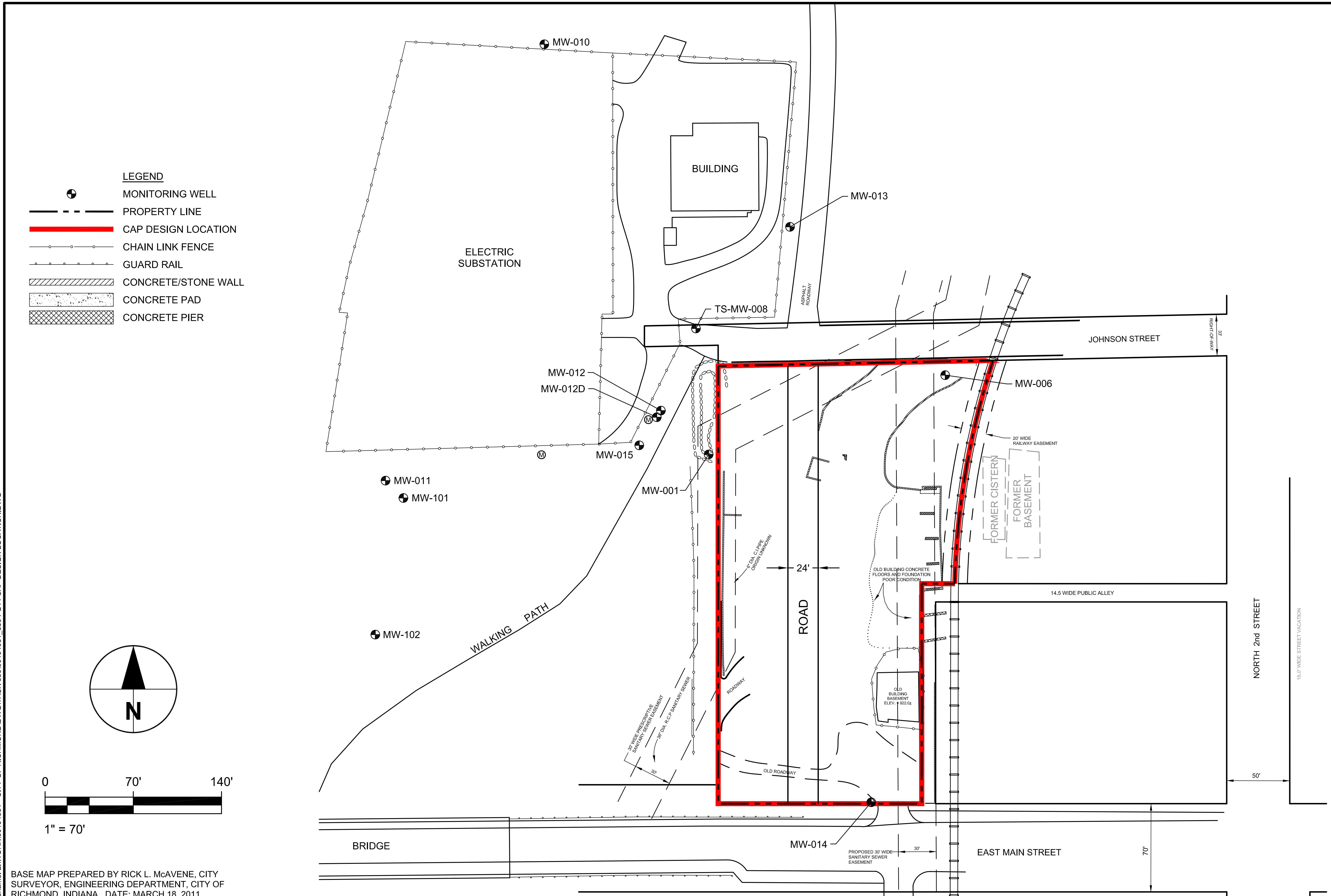

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Figure: 14

CAP DESIGN LOCATION

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-25

Last saved by: WILZBACHERN(2012-09-25) Last Plotted: 2012-09-25
Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG14 CAP DESIGN LOCATION.DWG

Project Management Initials: Designer: NLW Checked: NC Approved: ____ ANSI B 11" x 17"

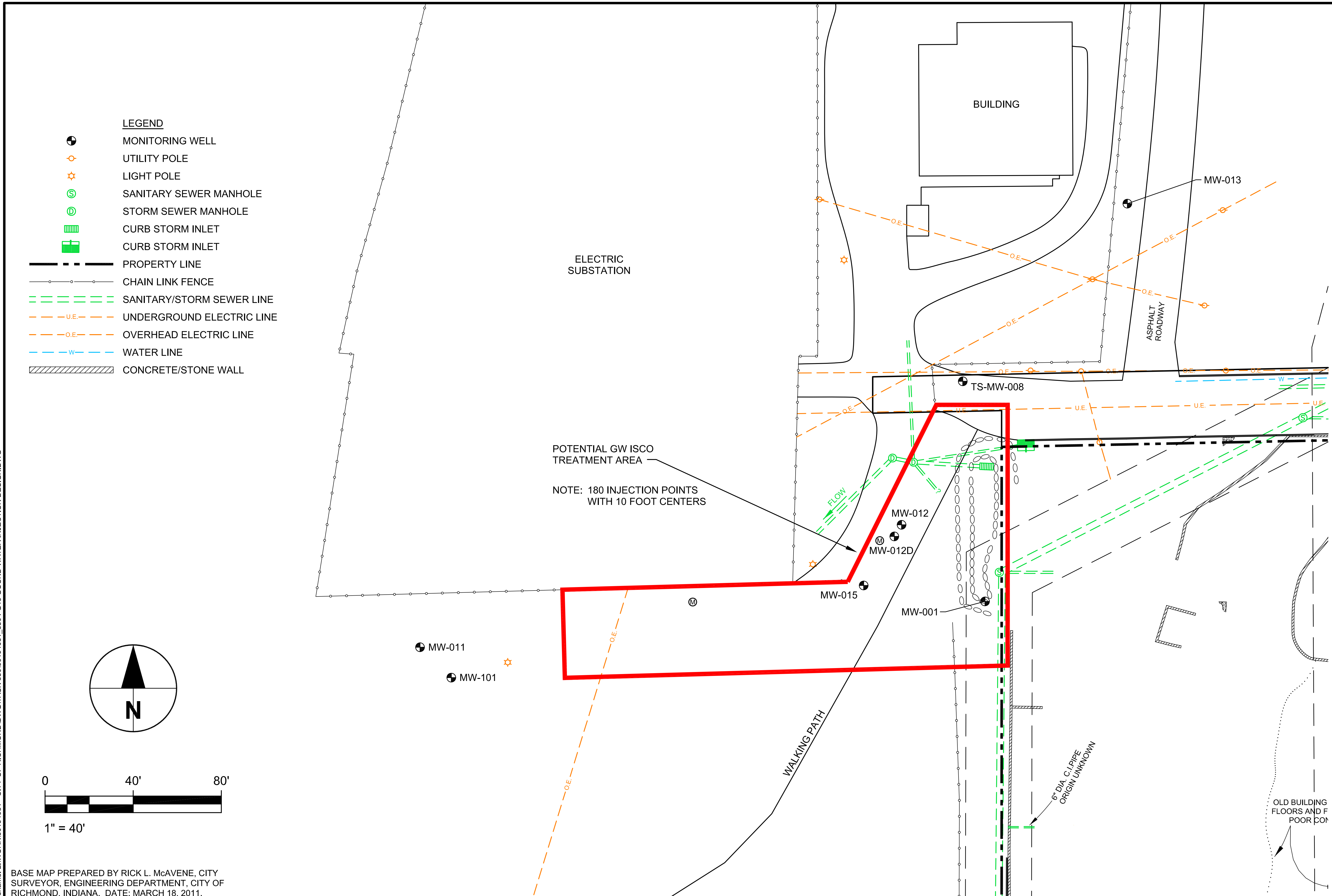

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Figure: 15

GROUND WATER INJECTION DESIGN

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-26

Project Management Initials: Designer: NLW Checked: NC Approved: ANSI B 11" x 17"

Last saved by: WILZBACHERN(2012-09-26) Last Plotted: 2012-09-26
Filename: L:\WORK\60194081 - CITY OF RICHMOND\DWG\TASK 850\60194081_850 FG15 GOUND WATER INJECTION DESIGN.DWG

Appendix A

Boring Logs and Well Completion Diagrams

Boring Log

Boring #: SB-MW-009
Sheet 1 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543435.31** Easting: **1669843.61**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **908.95**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **23**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-MW-009 (0-4)		1.1	0.0	0	FILL		Fill, topsoil material, sandy, some fine gravel, dry, brown, no odor	908	
								906	
SB-MW-009 (4-8)		0.9	0.2	5				904	
								902	
SB-MW-009 (8-12)		1.2	0.1		FILL		Fill, coarse gravel	900	
				10	ML		Sandy Silt, slightly stiff, brittle-like, medium and coarse sand, dampt to moist, light yellow-brown, no odor		

AECOM Environment
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268
Phone: (317) 735-3030
Fax: (317) 735-3040

Remarks: **Refusal at approximately 23 feet**

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Boring Log

Boring #: SB-MW-009
Sheet 2 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543435.31** Easting: **1669843.61**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **908.95**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **23**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10	ML		See previous page for lithology information	898	
SB-MW-009 (12-16)		2.4	0.2					896	
					CL		Silty Clay, stiff, non-plastic, cohesive, some coarse gravel fragments, damp, yellow-brown, no odor		
				15	CL		Clay, stiff, non-plastic, cohesive, trace medium sand and fine sub-rounded gravel, damp to moist, dark red-brown, no odor, coarse gravel fragments at bottom of interval	894	
SB-MW-009 (16-20)		2.3	0.8					892	
				20	CL		Clay, stiff, brittle, some silt, trace medium to coarse sand, few fine sub-rounded gravel, damp to moist, light yellow-brown, no odor	890	

Remarks: **Refusal at approximately 23 feet**

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Boring Log

Boring #: SB-MW-009

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543435.31** Easting: **1669843.61**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **908.95**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **23**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample				Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
Interval	Blow Counts	Recovery (feet)	PID (ppm)						
SB-MW-009 (20-24)		**1.3**	**1.1**	**20**	CL		See previous page for lithology information	888	
					LS		Limestone, pulverized, damp to dry, dark grey, no odor	886	

Remarks: **Refusal at approximately 23 feet**

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Boring Log

Boring #: SB-12-01
Sheet 1 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543054.45** Easting: **1669583.96**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **898.10**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-12-01 (0-4)		**1.9**	**0.2**	0	FILL		Fill, topsoil material, dark brown, dry	898	
					FILL		Fill, medium sand, some fine rounded gravel, damp, light brown, no odor		
					FILL		Fill, medium and coarse sand, some slag and cinder-like material, damp to dry, black, no odor	896	
					FILL		Fill, silt, very low plasticity, non-cohesive, some medium and coarse sand, damp, dark brown, no odor Sand content increases at 4 feet		
SB-12-01 (4-8)		**1.5**	**0.3**	5				894	
					FILL		Fill, sandy silt, fine sand, soft, non-plastic, non-cohesive, damp, light orange-brown, no odor	892	
					FILL		Fill, silt, very low plasticity, non-cohesive, some medium and coarse sand, some red brick fragments, damp, dark brown, no odor		
SB-12-01 (8-12)		**1.6**	**0.2**					890	
				10				888	

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Remarks:

Boring Log

Boring #: SB-12-01

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543054.45** Easting: **1669583.96**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **898.10**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10	FILL	See previous page for lithology information	888	
SB-12-01 (12-16)		0.9	0.4		SW	Sand, well sorted, medium and coarse, some fine sub-rounded gravel, abundant fines, damp to moist, light yellow-brown, no odor	886	
					SP	Sand, poorly sorted, fine, some fines, wet to saturated, light brown, faint hydrocarbon odor	884	
				15				
SB-12-01 (16-20)		1.8	5.3			Some coarse sand beginning at 16 feet Saturated at approximately 16.5 feet	882	
					GW	Gravel, well sorted, fine and coarse, some medium and coarse sand, abundant fines, saturated, yellow-brown grading to yellow-grey, light hydrocarbon odor, small amount of spotty sheen on soil	880	
				20			878	

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Remarks:

Boring Log

Boring #: SB-12-01
Sheet 3 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543054.45** Easting: **1669583.96**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **898.10**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				20				878	
SB-12-01 (20-24)		**2**	**18.2**		SP		Sand, poorly sorted, coarse sand with fine rounded gravel, some medium sand, some fines, saturated, grey, light to moderate hydrocarbon odor, moderate sheen on soil		
								876	
							Increased medium sand at 23 feet		
SB-12-01 (24-28)		**2.9**	**1.3**		SW		Sand, well sorted, medium and coarse, trace fine rounded gravel, trace fines, saturated, light odor, light sheen on soil	874	
				25					
								872	

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Remarks:

Boring Log

Boring #: SB-12-02
Sheet 1 of 4

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543434.52** Easting: **1669678.98**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **927.00**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **32**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-12-02 (0-4)		0.3	3.3	0	FILL		Fill, gravel and brick fragments, very loose, dry, no odor	926, 924	
SB-12-02 (4-8)		0.6	5.9	5	FILL		Fill, slag and cinder-like material, very loose, dry, black, faint hydrocarbon odor	922, 920, 918	
SB-12-02 (8-12)		1.0	5.7						
				10	FILL		Fill, crushed red brick		

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Remarks: **Sample soil from 24'-26' for BTEX, PAHs, and TOC**

Collect undisturbed soil sample from 24'-28' for porosity, permeability, and grain size

Boring Log

Boring #: SB-12-02
Sheet 2 of 4

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543434.52** Easting: **1669678.98**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **927.00**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **32**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10	FILL		Fill, sandy clay, very stiff, brittle-like, coarse sand, some fine angular gravel, damp to dry, yellow-brown, no odor	916	
SB-12-02 (12-16)		**1.0**	**21.9**		FILL		Fill, medium and coarse sand with fine angular gravel, loose, abundant fines, some red and pink brick fragments, some cinder-like material, damp to dry, black, light to moderate burnt-like odor	914	
				15				912	
SB-12-02 (16-20)		**0.9**	**20.6**					910	
								908	
				20					

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Remarks: **Sample soil from 24'-26' for BTEX, PAHs, and TOC**

Collect undisturbed soil sample from 24'-28' for porosity, permeability, and grain size

Boring Log

Boring #: SB-12-02
Sheet 3 of 4

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543434.52** Easting: **1669678.98**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **927.00**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **32**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-12-02 (20-24)		1.0	18.2	20	FILL	See previous page for lithology information		
					FILL	Fill, coarse gravel fragments	906	
					CL	Clay, soft to slightly stiff, low to medium plasticity, cohesive, trace coarse sand and fine gravel, moist, stained light olive-grey, moderate hydrocarbon odor	904	
SB-12-02 (24-28)		1.1	45.7	25		Moderate to strong hydrocarbon odor with few globules of black oil-like material from approximately 24.5'-25'	902	
							900	
SB-12-02 (28-32)		1.1	83.1					
					CL	Clay, stiff, low plasticity, cohesive, large amount of pulverized limestone, moist, light yellow-brown, light hydrocarbon odor	898	
				30				

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Remarks:
Sample soil from 24'-26' for BTEX, PAHs, and TOC
Collect undisturbed soil sample from 24'-28' for porosity, permeability, and grain size

Boring Log

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543434.52** Easting: **1669678.98**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **927.00**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **32**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample				Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
Interval	Blow Counts	Recovery (feet)	PID (ppm)						
				30	CL		See previous page for lithology information	896	

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Remarks:

Sample soil from 24'-26' for BTEX, PAHs, and TOC

Collect undisturbed soil sample from 24'-28' for porosity, permeability, and grain size

Boring Log

Boring #: SB-12-03
Sheet 1 of 2

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543310.35** Easting: **1669666.28**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **903.87**
Start Date: **8/1/12**	Method: **Direct Push**	Total Depth (ft): **16**
Finish Date: **8/1/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-12-03 (0-4)		2.5	0.8	0	FILL		Fill, 0.6' asphalt followed by gravel bedding		
					FILL		Fill, slag and cinder-like material, dry, black, no odor	902	
					FILL		Fill, fine sand, loose, dry, light brown, no odor		
					FILL		Fill, crushed red brick, no odor		
SB-12-03 (4-8)		1.8	77.4		FILL		Fill, medium and coarse sand with fine angular gravel, dry, no odor	900	
					FILL		Fill, red brick, no odor		
				5	FILL		Fill, slag and cinder-like material, some medium sand, dry, black, no odor	898	
					FILL		Fill, medium and coarse sand with fine angular gravel, dry, no odor		
					FILL		Fill, coarse gravel fragments, no odor		
					FILL		Fill, sand, medium and coarse, clayey, loose, moist, dark brown, light to moderate hydrocarbon odor Bottom 0.3 foot is wet with dark grey staining	896	
SB-12-03 (8-12)		1.9	349.1		FILL		Fill, clay, soft, non-plastic, cohesive, few to some medium and coarse sand, few cinder-like material, moist, stained very dark grey, moderate to strong hydrocarbon odor		
					FILL		Fill, sand, medium and coarse, few fines, trace cinder-like material, loose, damp, dark brown, no odor		
				10	CL			894	

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Remarks:

Boring Log

Boring #: SB-12-03
Sheet 2 of 2

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543310.35** Easting: **1669666.28**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **903.87**
Start Date: **8/1/12**	Method: **Direct Push**	Total Depth (ft): **16**
Finish Date: **8/1/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10			Clay, slightly stiff, low plasticity, cohesive, trace fine sand and coarse sub-angular gravel, moist, stained dark grey, moderate hydrocarbon odor		
SB-12-03 (12-16)		3.5	306.8					892	
							Grades to olive-grey with globules of black oil-like material beginning at approximately 13 feet, moist to wet, moderate to strong hydrocarbon odor	890	
				15				888	

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Remarks:

Boring Log

Boring #: SB-12-04
Sheet 1 of 2

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543311.42** Easting: **1669625.75**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **906.68**
Start Date: **8/1/12**	Method: **Direct Push**	Total Depth (ft): **20**
Finish Date: **8/1/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-12-04 (0-4)		2.8	2.4	0	FILL	Fill, 0.5' asphalt followed by gravel bedding	906	
					FILL	Fill, clay, dry, yellow-brown, no odor		
					FILL	Fill, coarse gravel fragments, no odor		
					FILL	Fill, medium and coarse sand and coarse gravel, loose, dry, brown, no odor		
					FILL	Fill, medium and coarse sand, trace to some fine sub-rounded gravel, damp to dry, dark brown, no odor Few cinder-like material at 4 feet	904	
SB-12-04 (4-8)		0.6	2.4	5			902 900	
SB-12-04 (8-12)		0.9	12.4				898	
				10	FILL	Fill, medium and coarse sand, trace fine sub-angular gravel, some fines, trace red brick fragments, damp, very dark brown mixed with some light brown, no odor		

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Remarks:

Boring Log

Boring #: SB-12-04
Sheet 2 of 2

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543311.42** Easting: **1669625.75**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **906.68**
Start Date: **8/1/12**	Method: **Direct Push**	Total Depth (ft): **20**
Finish Date: **8/1/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample				Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
Interval	Blow Counts	Recovery (feet)	PID (ppm)						
				10	FILL		See previous page for lithology information	896	
SB-12-04 (12-16)		2.8	52.3		CL		Clay, stiff, low plasticity, cohesive, little medium to coarse sand, moist, dark brown to dark olive-brown, moderate hydrocarbon odor, some dark yellow-brown oil-like material	894	
				15				892	
SB-12-04 (16-20)		3.0	27.1				Grades to greyish olive-brown at with decreasing odors and no oil-like material at 16 feet, increased coarse sand content	890	
								888	
				20	GP		Gravel, coarse fragments, dark grey-brown, no odor		

Remarks:

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Boring Log

Boring #: SB-12-05
Sheet 1 of 2

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543309.54** Easting: **1669550.36**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **912.96**
Start Date: **8/1/12**	Method: **Direct Push**	Total Depth (ft): **16**
Finish Date: **8/1/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
SB-12-05 (0-4)		2.5	9.0	0	FILL		Fill, 0.5' asphalt followed by gravel bedding	912	
					FILL		Fill, coarse sand and fine sub-angular gravel, abundant fines, damp to moist, dark brown, no odor	910	
SB-12-05 (4-8)		0.9	3.1	5			Few red brick fragments and trace cinder-like material beginning at 4 feet	908	
								906	
SB-12-05 (8-12)		1.4	13.8		FILL		Fill, coarse gravel, no odor	904	
				10	CL		Clay, stiff, low to medium plasticity, cohesive, trace coarse sand, moist, light olive, faint to light hydrocarbon and burnt-like odor		

Remarks:

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Boring Log

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**	
Project #: **60194081**	Operator: **R. Mores**	Northing: **543309.54**	Easting: **1669550.36**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **912.96**	
Start Date: **8/1/12**	Method: **Direct Push**	Total Depth (ft): **16**	
Finish Date: **8/1/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**	

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10	CL		See previous page for lithology information	902	
SB-12-05 (12-16)		2.4	328.7				Some coarse gravel fragments beginning at 12 feet, few globules of black oil-like material from approximately 12.5'-13.5', moderate hydrocarbon odor, becoming stiffer with depth	900	
				15	LS		Limestone, weathered, dark grey, saturated, no odor	898	

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Remarks:

Boring Log

Boring #: MW-010
Sheet 1 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543180.15** Easting: **1670002.66**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **899.26**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-010 (0-4)		1.7	0.0	0	FILL		Fill, topsoil material, trace fine gravel, stiff, dry, very dark brown, no odor	898	
					FILL		Fill, clayey silt, stiff, brittle, trace fine sub-angular gravel, dry, medium to light brown, no odor		
					FILL		Fill, fine and medium sand, trace slag and cinder-like material, dry, dark brown, no odor	896	
MW-010 (4-8)		0.5	0.4				Red brick fragments beginning at 4'		
				5				894	
								892	
MW-010 (8-12)		2.2	0.0		FILL		Fill, red brick		
					ML		Silt, slightly stiff, very low plasticity, cohesive, some fine sand, moist, brown, no odor	890	
				10					

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Remarks:

Boring Log

Boring #: MW-010

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543180.15** Easting: **1670002.66**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **899.26**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10	ML		See previous page for lithology information	888	
MW-010 (12-16)		2.8	0.1						
					GW		Gravel, well graded, fine to coarse angular to subangular gravel, fine to coarse sand, some fines, damp, light brown, no odor	886	
				15				884	
MW-010 (16-20)		1.9	0.0						
							Becomes moist to wet at approximately 17 feet	882	
							Becomes saturated at approximately 18 feet		
				20				880	

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Boring Log

Boring #: MW-010

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543180.15** Easting: **1670002.66**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **899.26**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-010 (20-24)		2.0	0.0	20	GW		See previous page for lithology information Increasing fines and coarse gravel content beginning at 20 feet	878	
								876	
MW-010 (24-28)		1.0	0.0	25				874	
								872	

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Remarks:

Boring Log

Boring #: MW-011

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543053.76** Easting: **1669654.91**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **899.02**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)
MW-011 (0-4)		2.1	3.8	0	FILL	Fill, topsoil material followed immediately by sandy gravelly fill material, damp to dry, dark brown, no odor	
					FILL	Fill, fine to coarse sand, some fines, abundant slag and cinder-like material, dry, black, no odor	898
					FILL	Fill, silt, slightly stiff, very low plasticity, cohesive, trace fine sand, damp to moist, brown, no odor	896
MW-011 (4-8)		0.4	12.1	5	FILL	Fill, fine and medium sand, some fines, very loose, trace red brick fragments, dry, dark brown, no odor	894, 892
MW-011 (8-12)		2.1	315.8	10	ML	Clayey Silt, very soft, low plasticity, cohesive, trace medium and coarse sand, saturated, stained black, strong hydrocarbon odor, some dark red-brown globules of oil-like material along the edges of the core	890

Well Construction Detail

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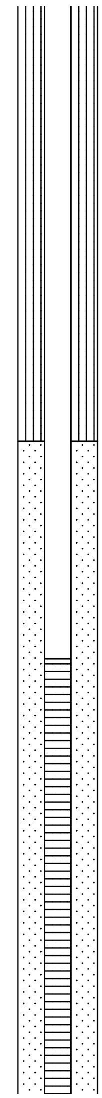
Boring Log

Boring #: MW-011

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543053.76** Easting: **1669654.91**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **899.02**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)
				10	SM		Silty Sand, slightly stiff, non-plastic, cohesive, fine sand, moist to wet, brown with dark grey staining, strong hydrocarbon odor	888
MW-011 (12-16)		2.0	143.8				Slight sheen on the soil beginning at 12'	
					SW		Sand, well graded, fine and medium, some coarse sand and fine sub-angular gravel, some fines increasing to 15.5' and then greatly decreasing, damp to moist, orange-brown grading to light brown, faint to no odor	886
				15			Small zone of dark grey staining from 15'-15.5' with moderate hydrocarbon odor	884
MW-011 (16-20)		2.1	155.7				Increasing coarse sand and fine gravel content beginning at approximately 16 feet	882
							Becomes wet at approximately 18 feet	
							Becomes saturated at approximately 19' with few dark brown globules of oil-like material, increasing odor	880
				20				

Well Construction Detail



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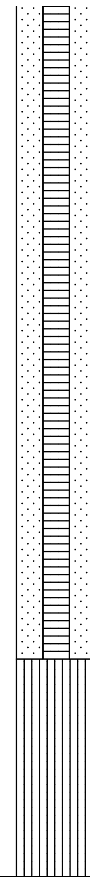
Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543053.76** Easting: **1669654.91**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **899.02**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-011 (20-24)		2.0	42.0	20	SP		Sand, poorly graded, coarse, some fine sub-rounded gravel, little medium sand, abundant fines, saturated, grey, strong hydrocarbon odor, several small black globules of oil-like material at approximately 23 feet	878 876	
MW-011 (24-28)		2.2	38.5	25	SP		Sand, poorly graded, medium sand, trace coarse sand and fine sub-rounded gravel, trace fines, saturated, grey, strong hydrocarbon odor, few globules of oil-like material throughout Grades to coarse sand and fine sub-rounded gravel, trace medium sand, decreasing amount of oil-like material with depth Zone of greatly increased fines from approximately 26.5'-27.5'	874 872	



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Boring Log

Boring #: MW-012D

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **B. Judy**	Northing: **543268.78** Easting: **1669704.62**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **900.41**
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **36**
Finish Date: **8/16/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)
MW-012D (0-2)	5/9 5/5	1.7	1.5	0	FILL	Fill, topsoil material, damp to dry, dark brown, no odor	900
					FILL	Fill, clayey sand, some coarse gravel fragments, some red brick fragments and cinder-like material, loose, damp to moist, dark brown to black, faint burnt-like odor	
					FILL	Fill, silty clay, soft, low plasticity, cohesive, some fine angular gravel, moist, yellow-brown, no odor	
MW-012D (2-4)	3/2 2/4	0			FILL	No recovery	898
MW-012D (4-6)	2/1 1/2	0.7	23.2	5	FILL	Fill, clay, soft, non-plastic, cohesive, some coarse gravel fragments, trace red brick fragments and fine sand, moist, dark brown, no odor	896
MW-012D (6-8)	7/5 3/5	1.1	187		SM	Silty Sand, fine, non-cohesive, loose, moist to wet, stained black, strong hydrocarbon odor, small amount of sheen on soil	894
					CL	Clay, soft to slightly stiff, low to medium plasticity, cohesive, moist to wet, stained dark grey, strong hydrocarbon odor, dark brown globules of oil-like material thoughout	
MW-012D (8-10)	6/3 3/4	1	128	10		Some fine angular gravel beginning at 8'	892

Well Construction Detail

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Boring #: MW-012D

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **B. Judy**	Northing: **543268.78** Easting: **1669704.62**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **900.41**
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **36**
Finish Date: **8/16/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)
MW-012D (10-12)	4/5 5/7	1.4	114	10	CL	See previous page for lithology information Slightly increased gravel content with some mottling beginning at 10'	890
MW-012D (12-14)	4/3 3/5	1.5	333			Grades to dark green-grey beginning at 12', no gravel, slightly increased hydrocarbon odor, dark brown globules of oil-like material	888
MW-012D (14-16)	2/2 2/2	1.4	126			Grades to dark brown to brown beginning at 14', few globules of oil-like material, moderate to strong hydrocarbon odor	886
				15	SM	Silty Sand, fine, some medium sand, soft, non-cohesive, wet to saturated, yellow-brown to brown, moderate to strong hydrocarbon odor, some dark brown globules of oil-like material throughout bottom 0.2'	
					SP	Sand, poorly graded, fine, some fines, loose, saturated, dark brown with some black staining, strong hydrocarbon odor, sheen on soil	
					SM	Silty Sand, fine, some medium sand, soft, non-cohesive, wet to saturated, yellow-brown to brown, moderate to strong hydrocarbon odor	
MW-012D (16-18)	7/8 29/16	0.8	142		SW	Sand, well graded, fine to coarse, some fine sub-angular gravel, abundant fines, moist to wet, stained black, moderate to strong hydrocarbon odor, dark yellow-brown oil-like material thoughout bottom 0.1'	884
MW-012D (18-20)	8/11 14/17	1	238		SW	Sand, well graded, medium and coarse sand, some coarse gravel fragments, some fines, moist, yellow-brown with some dark grey staining, moderate hydrocarbon odor, some dark yellow-brown globules of oil-like material	882
				20			

Well Construction Detail

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Remarks:

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Boring #: MW-012D

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **B. Judy**	Northing: **543268.78** Easting: **1669704.62**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **900.41**
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **36**
Finish Date: **8/16/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)
MW-012D (20-22)	30/14 30/24	1	87.4	20	GW	Gravel, well graded, fine to coarse, sub-rounded, some coarse sand, some to abundant fines, saturated, dark grey, moderate to strong hydrocarbon odor, few dark brown globules of oil-like material throughout	880
MW-012D (22-24)	36/24 27/19	1	17.4				878
					LS	Limestone, highly weathered fragments with some clay, saturated, grey, light to moderate hydrocarbon odor, few small dark brown globules of oil-like material from 22'-24'	
MW-012D (24-26)	50 for 5"	0.2		25			876
MW-012D (26-28)	21/18 20/22	1	29			At 26' becomes slightly darker grey, faint odor, slight sheen on soil	874
					SP	Sand, poorly graded, medium, some coarse sand, trace fine rounded gravel, some fines, saturated, light yellow-brown, faint to no odor, slight orange staining bottom 0.2'	
MW-012D (28-30)	14/20 17/21	0.6	10.8		LS	Limestone, highly weathered fragments with some clay, saturated, light grey, faint odor	872
				30			

Remarks:

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Boring Log

Boring #: MW-012D

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**	
Project #: **60194081**	Operator: **B. Judy**	Northing: **543268.78**	Easting: **1669704.62**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **900.41**	
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **36**	
Finish Date: **8/16/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**	

Sample				Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
Interval	Blow Counts	Recovery (feet)	PID (ppm)						
MW-012D (30-32)	17/36 42/40	**1.2**	**6.9**	**30**	LS		See previous page for lithology information	870	
					LS		Limestone, fragmented but becoming more competent, some fines, saturated, dark grey limestone with light yellow-brown fines, faint to no odor		
MW-012D (32-34)	15/25 36/24	**0.3**	**0.6**					868	
MW-012D (34-36)	10/20 33/50 for 4"	**0.3**	**0.2**					866	
				35					

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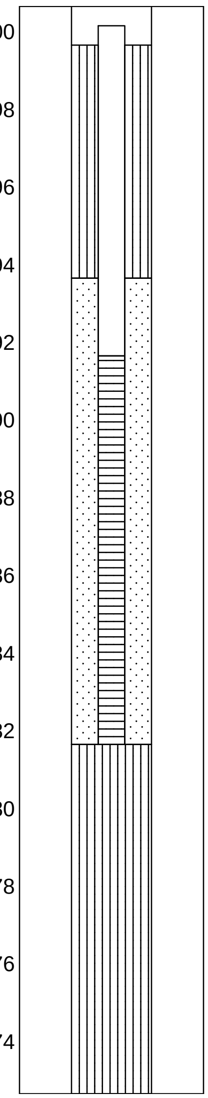
Remarks:

Boring Log

Boring #: MW-012S
Sheet 1 of 1

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543271.83** Easting: **1669710.27**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **900.66**
Start Date: **7/30/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/30/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-012 (0-4)			0.4	0			See lithology description in MW-012D boring log to 28 feet	900	
								898	
MW-012 (4-8)			190.4	5				896	
								894	
MW-012 (8-12)			182.7					892	
				10				890	
MW-012 (12-16)			416.5					888	
				15				886	
MW-012 (16-20)			398.6					884	
								882	
MW-012 (20-24)			130	20				880	
								878	
MW-012 (24-28)			76.8	25				876	
								874	



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Remarks:

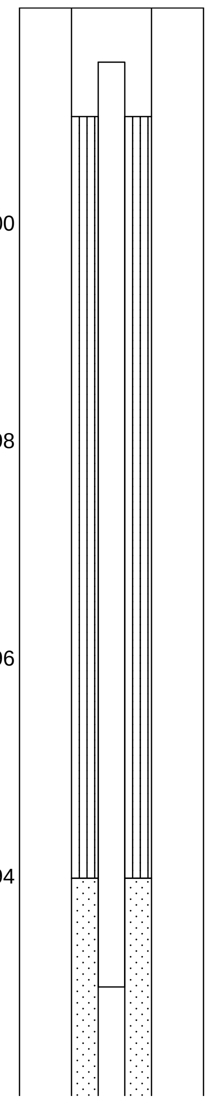
Boring Log

Boring #: MW-013

Sheet 1 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543374.23** Easting: **1669857.13**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **901.98**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-013 (0-4)		2.7	3.9	0	FILL		Fill, topsoil material, some coarse angular gravel fragments, dry, brown, no odor		
					FILL		Fill, red brick		
					FILL		Fill, clay, slightly stiff, low plasticity, cohesive, some coarse gravel fragments, trace red brick fragments, damp to moist, very dark grey, no odor	900	
MW-013 (4-8)		3.2	3					898	
				5				896	
MW-013 (8-12)		0.8	3.2				At 8' becomes wet and soft, some coarse sand, few glass fragments, wet to saturated, no odor, no gravel or brick fragments	894	
				10				892	



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Remarks:

Boring Log

Boring #: MW-013
Sheet 2 of 3

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543374.23** Easting: **1669857.13**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **901.98**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
				10	FILL		See previous page for lithology information	892	
MW-013 (12-16)		3.3	6.6		CL		Clay, slightly stiff, low to medium plasticity, cohesive, trace increasing to some coarse sand, moist, dark brown, no odor	890	
								888	
				15					
MW-013 (16-20)		3.2	6.9		CL		Clay, soft to slightly stiff, medium plasticity, cohesive, trace medium sand, moist to wet, dark brown grading quickly to olive-brown with some grey streaking, faint hydrocarbon odor	886	
								884	
					SM		Silty Sand, fine, some coarse sand and fine sub-angular gravel, soft, non-cohesive, saturated, light yellow-brown, no odor		
				20				882	

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Remarks:

Boring Log

Boring #: MW-013

Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543374.23** Easting: **1669857.13**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **901.98**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **28**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-013 (20-24)		1.3	3.7	20	SM		Silty Sand, coarse, some medium sand and coarse sub-angular gravel, saturated, yellow-brown grading to light brown, no odor	882	
								880	
MW-013 (24-28)		1.4	4.2					878	
				25				876	
					LS		Limestone, pulverized fragments, damp to dry, dark grey, no odor	874	

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Remarks:

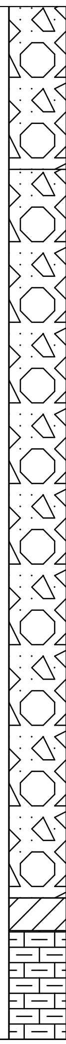
Boring Log

Boring #: MW-014
Sheet 1 of 1

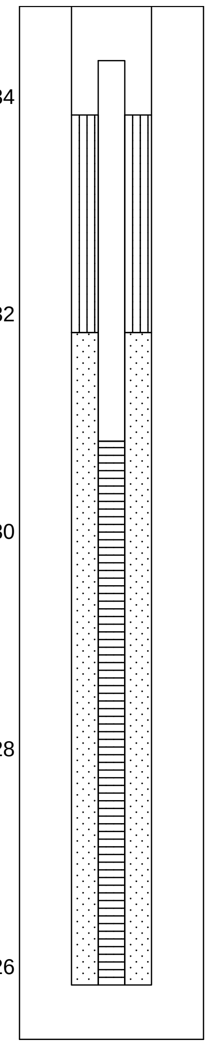
Project: **Richmond Former MGP**	Contractor: **Enviro-Dynamics**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **R. Mores**	Northing: **543439.64** Easting: **1669400.22**
Client: **City of Richmond**	Drill Rig Type: **Geoprobe 6610D**	Surface Elevation (ft MSL): **934.83**
Start Date: **7/31/12**	Method: **Direct Push**	Total Depth (ft): **9.5**
Finish Date: **7/31/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample: Interval	Sample: Blow Counts	Sample: Recovery (feet)	Sample: PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)
MW-014 (0-4)		**2.8**	**5**	0	FILL	Fill, coarse gravel fragments	934
					FILL	Fill, fine and medium sand, damp, brown to light brown, no odor	932
MW-014 (4-8)		**2.7**	**2.4**	5			930
						Becomes moist at approximately 5.5 feet	
						Becomes wet at approximately 7.5 feet with very faint hydrocarbon odor, some fines	928
MW-013 (8-12)		**1.6**	**2.8**			Becomes saturated at approximately 8 feet	
					CL	Sandy Clay, slightly stiff, non-plastic, cohesive, coarse sand, trace fine sub-angular gravel, saturated, yellow-brown, faint hydrocarbon odor	926
					LS	Limestone, pulverized fragments, damp to dry, dark grey, no odor	

Lithology



Well Construction Detail



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Remarks: **Refusal encountered at 9.5 feet**

Boring Log

Boring #: MW-015

Sheet 1 of 3

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **B. Judy**	Northing: **543254.58** Easting: **1669683.83**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **899.67**
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **26**
Finish Date: **8/17/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description
MW-015 (0-2)	9/4 5/5	0.3	0.9	0	FILL	Fill, topsoil material, some coarse gravel, damp to dry, dark brown, no odor
MW-015 (2-4)	1/2 2/3	0.9	0.0		FILL	Fill, clay, soft, non-plastic, cohesive, some coarse sand and coarse gravel fragments, trace red brick fragments, damp to moist, dark brown, faint hydrocarbon odor
MW-015 (4-6)	2/2 2/2	0.5	0.0			Trace cinder-like material from 4'-6'
				5		
MW-015 (6-8)	1/1 1/2	0.2	14.9			At 6' becomes wet to saturated, stained dark grey, few fine gravel, few dark brown globules of oil-like material, moderate hydrocarbon odor
MW-015 (8-10)	1/1 1/1	1.7	65.7		FILL	Fill, medium and coarse sand, abundant fines, saturated in black oil-like material, moderate to strong hydrocarbon odor
					CL	Clay, soft, medium plasticity, cohesive, dark grey with black mottling, moist to wet, top 0.7' stained black, bottom 0.2' contains few dark brown globules of oil-like material, moderate to strong hydrocarbon odor
				10		

Elevation (ft MSL): 898, 896, 894, 892, 890

Well Construction Detail

AECOM Environment
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268
Phone: (317) 735-3030
Fax: (317) 735-3040

Remarks:

Collect undisturbed soil sample from 14'-16' for porosity, permeability, and grain size

Collect soil sample from 22'-23' for BTEX, PAHs, and TOC

Collect soil sample from 23'-25' for BTEX, PAHs, and TOC

Boring Log

Boring #: MW-015
Sheet 2 of 3

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **B. Judy**	Northing: **543254.58** Easting: **1669683.83**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **899.67**
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **26**
Finish Date: **8/17/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Soil and Rock Description	Elevation (ft MSL)
MW-015 (10-12)	1/3 4/3	1.4	46.5	10	CL	See previous page for lithology informatoin Some black mottling beginning at 10' with few dark brown globules of oil-like material thoughout	
							888
MW-015 (12-14)	1/2 2/3	1.5	60.9			Grades to dark green-grey with black mottling beginning at 12', some dark brown globules of oil-like material thoughout, strong to very strong hydrocarbon odor	
							886
MW-015 (14-16)	1/2 3/7	1.5	91.2				
				15			
					CL	Sandy Clay, slightly stiff, non-plastic, cohesive, medium sand, some coarse sand and fine sub-angular gravel, wet to saturated, stained dark grey, few dark brown globules of oil-like material, moderate hydrocarbon odor	884
MW-015 (16-18)	12/26 27/41	1.5	79.4		CL	Clay, soft, low to medium plasticity, cohesive, wet to saturated, stained dark grey, moderate to strong hydrocarbon odor, coarse gravel fragments at bottom of interval	
					CL	Clay, slightly stiff, low plasticity, cohesive, medium sand, some coarse sand and fine sub-angular gravel, moist, yellow-brown, some dark grey and black staining, few dark brown globules of oil-like material, light hydrocarbon odor, coarse gravel fragments at bottom of interval	882
					SW	Sand, well graded, fine to coarse, some fine sub-angular gravel, some fines, damp to moist, stained grey to dark grey, light hydrocarbon odor	
MW-015 (18-20)	6/17 22/20	1.3	33.4		CL		
					GP		880
				20			

Well Construction Detail

AECOM Environment
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268
Phone: (317) 735-3030
Fax: (317) 735-3040

Remarks:
Collect undisturbed soil sample from 14'-16' for porosity, permeability, and grain size
Collect soil sample from 22'-23' for BTEX, PAHs, and TOC
Collect soil sample from 23'-25' for BTEX, PAHs, and TOC

Boring Log

Boring #: MW-015
Sheet 3 of 3

Project: **Richmond Former MGP**	Contractor: **Earth Exploration**	Location: **Richmond, IN**
Project #: **60194081**	Operator: **B. Judy**	Northing: **543254.58** Easting: **1669683.83**
Client: **City of Richmond**	Drill Rig Type: **HSA**	Surface Elevation (ft MSL): **899.67**
Start Date: **8/16/12**	Method: **Split Spoon**	Total Depth (ft): **26**
Finish Date: **8/17/12**	Sample Diameter (in): **2**	Logged By: **Nathan Conniff**

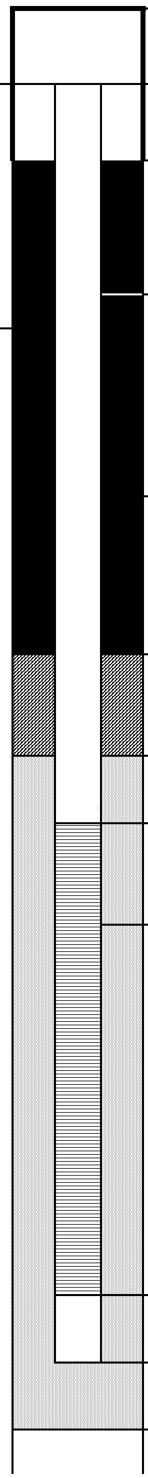
Sample Interval	Blow Counts	Recovery (feet)	PID (ppm)	Depth (ft)	USCS	Lithology	Soil and Rock Description	Elevation (ft MSL)	Well Construction Detail
MW-015 (20-22)	10/26 50 for 2"	0.5	25.2	20	CL		Sandy Clay, soft to slightly stiff, low plasticity, cohesive, medium to coarse sand, wet to saturated, stained dark grey, moderate to strong hydrocarbon odor		
							Gravel, poorly graded, coarse, some medium to coarse sand, some fines, damp to moist, orange-brown, light hydrocarbon odor	878	
MW-015 (22-24)	37/16 10/18	1.3	24.3				Sandy Clay, soft to slightly stiff, low plasticity, cohesive, medium to coarse sand, some coarse rounded gravel fragments, wet to saturated, stained dark grey, moderate to strong hydrocarbon odor		
MW-015 (24-26)	50/25 33/42	1.5	14.0	25	GW		Gravel, well graded, fine to coarse, sub-rounded, some coarse sand, abundant fines, saturated, grey to dark grey, moderate to strong hydrocarbon odor, few dark brown globules of oil-like material throughout	876 874	

AECOM Environment
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268
Phone: (317) 735-3030
Fax: (317) 735-3040

Remarks:
Collect undisturbed soil sample from 14'-16' for porosity, permeability, and grain size
Collect soil sample from 22'-23' for BTEX, PAHs, and TOC
Collect soil sample from 23'-25' for BTEX, PAHs, and TOC

AECOM	*Client:* City of Richmond	*WELL ID:* **MW-010**
	Project Number: 60194081	
	Site Location: Richmond Former MGP Site	*Date Installed:* 7/30/2012
	Well Location: *Coords:*	*Inspector:* Nathan Conniff
	Method: Hollow Stem Auger	*Contractor:* Enviro-Dynamics

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation (feet) Datum __________
Top of Steel Guard Pipe		
Top of Riser Pipe	0.21	899.05
Ground Surface (G.S.)	0.0	899.26
Bottom of Steel Guard Pipe		
Top of Bentonite	1.0	898.26
Top of Sand	14.0	885.26
Top of Screen	16.0	883.26
Stabilized Water Level	17.62	881.43
Bottom of Screen	26.0	873.26
Bottom of Tail Pipe:	26.2	873.06
Bottom of Borehole	26.2	873.06

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

____ % Cement

100 % Bentonite

____ % Native Materials

Riser Pipe:
- Length: 15.79 feet
- Inside Diameter (ID): 2 inch
- Type of Material: PVC

Bentonite Seal Thickness: 13 feet

Screen:
- Length: 10 feet
- Inside Diameter (ID): 2 inch
- Slot Size: 0.010 inch
- Type of Material: PVC

Type/Size of Sand: Global #5

Sand Pack Thickness: 12 feet

Borehole Diameter: 8 inch

Approved:

_______________ Signature

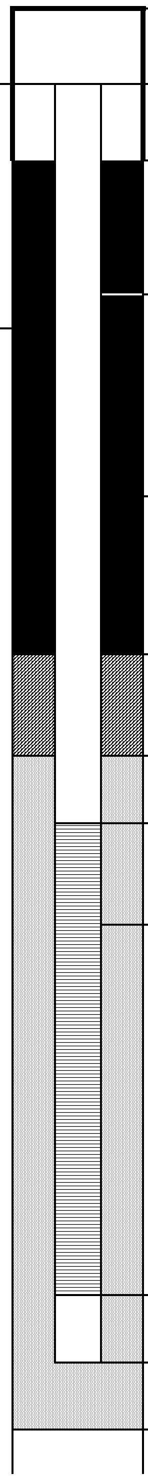
_______________ Date

Describe Measuring Point:

Ground Surface

AECOM	Client: City of Richmond	WELL ID: **MW-011**
	Project Number: 60194081	
	Site Location: Richmond Former MGP Site	Date Installed: 7/30/2012
	Well Location: Coords:	Inspector: Nathan Conniff
	Method: Hollow Stem Auger	Contractor: Enviro-Dynamics

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation (feet) Datum ____
Top of Steel Guard Pipe		
Top of Riser Pipe	0.13	898.89
Ground Surface (G.S.)	0.0	899.02
Bottom of Steel Guard Pipe		
Top of Bentonite	1.0	898.02
Top of Sand	14.0	885.02
Top of Screen	16.0	883.02
▼ Stabilized Water Level	18.13	880.76
Bottom of Screen	26.0	873.02
Bottom of Tail Pipe:	26.2	872.82
Bottom of Borehole	26.2	872.82

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

____ % Cement

100 % Bentonite

____ % Native Materials

Riser Pipe:
- Length: 15.87 feet
- Inside Diameter (ID): 2 inch
- Type of Material: PVC

Bentonite Seal Thickness: 13 feet

Screen:
- Length: 10 feet
- Inside Diameter (ID): 2 inch
- Slot Size: 0.010 inch
- Type of Material: PVC

Type/Size of Sand: Global #5

Sand Pack Thickness: 12 feet

Borehole Diameter: 8 inch

Approved:

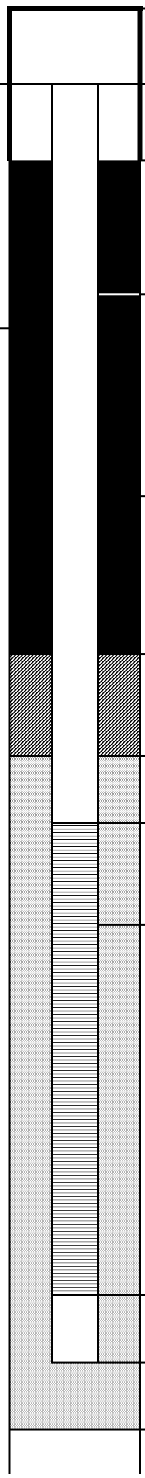
Signature ____ Date ____

Describe Measuring Point:

Ground Surface

AECOM	*Client:* City of Richmond	***WELL ID:* MW-012D**
	Project Number: 60194081	
	Site Location: Richmond Former MGP Site	*Date Installed:* 8/16/2012
	Well Location: *Coords:*	*Inspector:* Nathan Conniff
	Method: Hollow Stem Auger	*Contractor:* Earth Exploration

MONITORING WELL CONSTRUCTION DETAIL



Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

___ % Cement

100 % Bentonite

___ % Native Materials

	Depth from G.S. (feet)	Elevation (feet) Datum ______
Top of Steel Guard Pipe		
Top of Riser Pipe	0.08	900.33
Ground Surface (G.S.)	0.0	900.41
Bottom of Steel Guard Pipe		
Top of Bentonite	1.0	899.41
Top of Sand	8.0	892.41
Top of Screen	10.0	890.41
Stabilized Water Level	18.64	881.69
Bottom of Screen	30.0	870.41
Bottom of Tail Pipe:	30.2	870.21
Bottom of Borehole	36.0	864.41

Riser Pipe:
- Length: 9.92 feet
- Inside Diameter (ID): 2 inch
- Type of Material: PVC

Bentonite Seal Thickness: 7 feet

Screen:
- Length: 20 feet
- Inside Diameter (ID): 2 inch
- Slot Size: 0.010 inch
- Type of Material: PVC

Type/Size of Sand: Global #5

Sand Pack Thickness: 22 feet

Borehole Diameter: 8 inch

Approved:

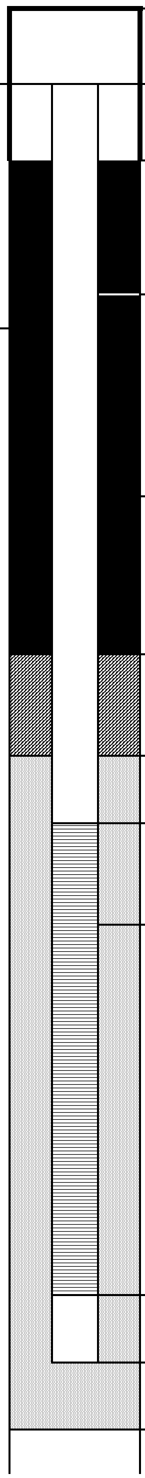
Signature ______ Date ______

Describe Measuring Point:

Ground Surface

AECOM			
	Client: City of Richmond		***WELL ID:*** **MW-012S**
	Project Number: 60194081		
	Site Location: Richmond Former MGP Site		*Date Installed:* 7/30/2012
	Well Location:	*Coords:*	*Inspector:* Nathan Conniff
	Method: Hollow Stem Auger		*Contractor:* Enviro-Dynamics

MONITORING WELL CONSTRUCTION DETAIL



Item		Depth from G.S. (feet)	Elevation (feet) Datum ______
Top of Steel Guard Pipe			
Top of Riser Pipe		0.52	900.14
Ground Surface (G.S.)		0.0	900.66
Riser Pipe:			
Length	8.48 feet		
Inside Diameter (ID)	2 inch		
Type of Material	PVC		
Bottom of Steel Guard Pipe			
Top of Bentonite		1.0	899.66
Bentonite Seal Thickness	6 feet		
Top of Sand		7.0	893.66
Top of Screen		9.0	891.66
▼ Stabilized Water Level			
Screen:			
Length	10 feet		
Inside Diameter (ID)	2 inch		
Slot Size	0.010 inch		
Type of Material	PVC		
Type/Size of Sand	Global #5		
Sand Pack Thickness	12 feet		
Bottom of Screen		19.0	881.66
Bottom of Tail Pipe:		19.2	881.46
Bottom of Borehole		19.2	881.46

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

___ % Cement

100 % Bentonite

___ % Native Materials

Borehole Diameter: 8 inch

Approved:

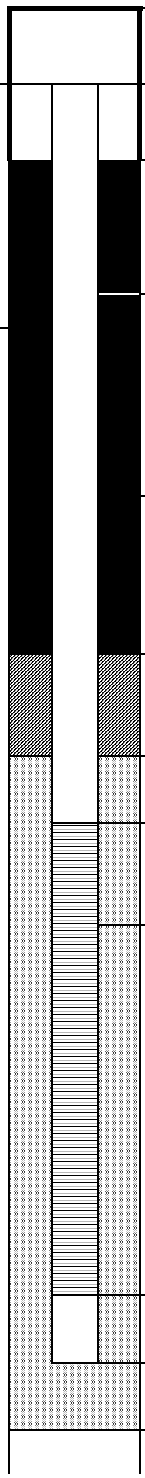
Signature ____________ Date ____________

Describe Measuring Point:

Ground Surface

AECOM		
	Client: City of Richmond	***WELL ID:*** **MW-013**
	Project Number: 60194081	
	Site Location: Richmond Former MGP Site	*Date Installed:* 7/31/2012
	Well Location: *Coords:*	*Inspector:* Nathan Conniff
	Method: Hollow Stem Auger	*Contractor:* Enviro-Dynamics

MONITORING WELL CONSTRUCTION DETAIL



Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

____ % Cement

100 % Bentonite

____ % Native Materials

	Depth from G.S. (feet)	Elevation (feet) Datum ________
Top of Steel Guard Pipe		
Top of Riser Pipe	0.3	901.98
Ground Surface (G.S.)	0.0	902.28
Bottom of Steel Guard Pipe		
Top of Bentonite	1.0	901.28
Top of Sand	8.0	894.28
Top of Screen	10.0	892.28
▼ Stabilized Water Level		
Bottom of Screen	20.0	882.28
Bottom of Tail Pipe:	20.2	882.08
Bottom of Borehole	28.0	874.28

Riser Pipe:

Length	9.7 feet
Inside Diameter (ID)	2 inch
Type of Material	PVC

Bentonite Seal Thickness: 7 feet

Screen:

Length	10 feet
Inside Diameter (ID)	2 inch
Slot Size	0.010 inch
Type of Material	PVC

Type/Size of Sand	Global #5
Sand Pack Thickness	12 feet

Borehole Diameter: 8 inch

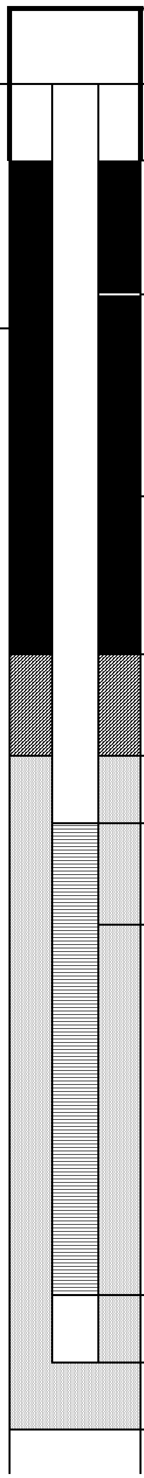
Approved: ____________________ Signature ____________ Date

Describe Measuring Point:

Ground Surface

AECOM	*Client:* City of Richmond	***WELL ID:*** **MW-014**
	Project Number: 60194081	
	Site Location: Richmond Former MGP Site	*Date Installed:* 7/31/2012
	Well Location: *Coords:*	*Inspector:* Nathan Conniff
	Method: Hollow Stem Auger	*Contractor:* Enviro-Dynamics

MONITORING WELL CONSTRUCTION DETAIL



Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

___ % Cement

100 % Bentonite

___ % Native Materials

	Depth from G.S. (feet)	Elevation (feet) Datum ______
Top of Steel Guard Pipe		
Top of Riser Pipe	0.04	934.79
Ground Surface (G.S.)	0.0	934.83
Bottom of Steel Guard Pipe		
Top of Bentonite	1.0	933.83
Top of Sand	3.0	931.83
Top of Screen	4.0	930.83
▼ Stabilized Water Level		
Bottom of Screen	9.0	925.83
Bottom of Tail Pipe:	9.2	925.63
Bottom of Borehole	9.5	925.33

Riser Pipe:

Length	3.96 feet
Inside Diameter (ID)	2 inch
Type of Material	PVC

Bentonite Seal Thickness: 2 feet

Screen:

Length	5 feet
Inside Diameter (ID)	2 inch
Slot Size	0.010 inch
Type of Material	PVC

Type/Size of Sand	Global #5
Sand Pack Thickness	7 feet

Borehole Diameter: 8 inch

Approved:

Signature ______________ Date ______________

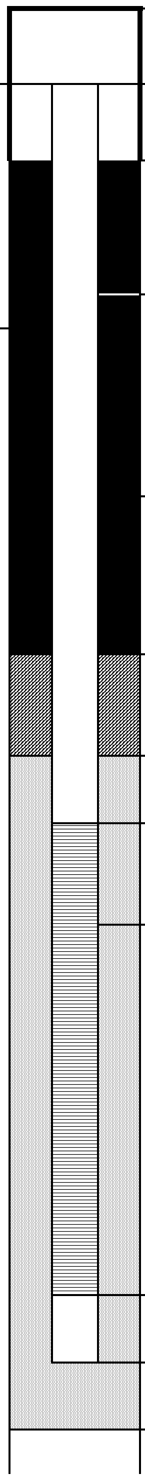
Describe Measuring Point:

Ground Surface

AECOM

Client: City of Richmond		*WELL ID:* **MW-015**	
Project Number: 60194081			
Site Location: Richmond Former MGP Site		*Date Installed:* 8/17/2012	
Well Location:	*Coords:*	*Inspector:* Nathan Conniff	
Method: Hollow Stem Auger		*Contractor:* Earth Exploration	

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation (feet) Datum ________
Top of Steel Guard Pipe		
Top of Riser Pipe	0.33	899.67
Ground Surface (G.S.)	0.0	900.00
Bottom of Steel Guard Pipe		
Top of Bentonite	1.0	899.00
Top of Sand	8.0	892.00
Top of Screen	10.0	890.00
▼ Stabilized Water Level	17.85	881.82
Bottom of Screen	25.0	875.00
Bottom of Tail Pipe:	25.2	874.80
Bottom of Borehole	26.0	874.00

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

___ % Cement

100 % Bentonite

___ % Native Materials

Riser Pipe:
- Length: 9.67 feet
- Inside Diameter (ID): 2 inch
- Type of Material: PVC

Bentonite Seal Thickness: 7 feet

Screen:
- Length: 15 feet
- Inside Diameter (ID): 2 inch
- Slot Size: 0.010 inch
- Type of Material: PVC

Type/Size of Sand: Global #5

Sand Pack Thickness: 17 feet

Borehole Diameter: 8 inch

Approved:

Signature ________________ Date ________________

Describe Measuring Point:

Ground Surface

Appendix B

Laboratory Analytical Reports and Chain-of-Custody Forms

Pace Analytical®
www.pacelabs.com

Pace Analytical Services, Inc.
1233 Dublin Road
Columbus, OH 43215
(614)486-5421

Pace Analytical Services, Inc.
7726 Moller Road
Indianapolis, IN 46268
(317)875-5894

August 17, 2012

Nathan Conniff
AECOM
8902 Vincennes Circle
Indianapolis, IN 46268

RE: Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Dear Nathan Conniff:

Enclosed are the analytical results for sample(s) received by the laboratory on August 03, 2012. 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.

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

Sincerely,

Lyle Cable

lyle.cable@pacelabs.com
Project Manager

Enclosures

cc: Jeffrey Nelson

Pace Analytical Services, Inc.
1233 Dublin Road
Columbus, OH 43215
(614)486-5421

Pace Analytical Services, Inc.
7726 Moller Road
Indianapolis, IN 46268
(317)875-5894

CERTIFICATIONS

Project:	Richmond former MGP 60194081
Pace Project No.:	5067059

Indiana Certification IDs

7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 200074
Indiana Certification #: C-49-06
Kansas Certification #: E-10247
Kentucky Certification #: 0042
Louisiana/NELAC Certification #: 04076
Ohio VAP Certification #: CL0065
Pennsylvania Certification #: 68-04991
West Virginia Certification #: 330

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7726 Moller Road
Indianapolis, IN 46268
(317)875-5894

SAMPLE SUMMARY

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Lab ID	Sample ID	Matrix	Date Collected	Date Received
5067059001	**MW-010**	Water	08/01/12 14:40	08/03/12 13:18
5067059002	**MW-102**	Water	08/01/12 17:20	08/03/12 13:18
5067059003	**MW-008**	Water	08/02/12 09:15	08/03/12 13:18
5067059004	**MW-101**	Water	08/02/12 11:35	08/03/12 13:18
5067059005	**MW-011**	Water	08/02/12 14:25	08/03/12 13:18
5067059006	**MW-006**	Water	08/02/12 15:55	08/03/12 13:18
5067059007	**DUP-01**	Water	08/02/12 08:00	08/03/12 13:18
5067059008	**TBK-01**	Water	08/02/12 08:00	08/03/12 13:18

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7726 Moller Road
Indianapolis, IN 46268
(317)875-5894

SAMPLE ANALYTE COUNT

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Lab ID	Sample ID	Method	Analysts	Analytes Reported
5067059001	**MW-010**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		EPA 335.4	ILP	1
5067059002	**MW-102**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		EPA 335.4	ILP	1
5067059003	**MW-008**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		EPA 335.4	ILP	1
5067059004	**MW-101**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		EPA 335.4	ILP	1
5067059005	**MW-011**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		EPA 335.4	ILP	1
5067059006	**MW-006**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		SM 3500-Fe D#4	TPD	1
		EPA 335.4	ILP	1
5067059007	**DUP-01**	EPA 6010	FRW	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	JLZ	7
		EPA 335.4	ILP	1
5067059008	**TBK-01**	EPA 8260	JLZ	7

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7726 Moller Road
Indianapolis, IN 46268
(317)875-5894

ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: MW-010 **Lab ID: 5067059001** Collected: 08/01/12 14:40 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:53	7440-38-2	
Barium	**131**	ug/L	100	1	08/06/12 10:00	08/07/12 12:53	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 12:53	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:53	7440-47-3	
Iron	**904**	ug/L	100	1	08/06/12 10:00	08/07/12 12:53	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:53	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:53	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 12:53	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 12:42	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	83-32-9	
Acenaphthylene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	208-96-8	
Anthracene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	120-12-7	
Benzo(a)anthracene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	56-55-3	
Benzo(a)pyrene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	50-32-8	
Benzo(b)fluoranthene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	205-99-2	
Benzo(g,h,i)perylene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	191-24-2	
Benzo(k)fluoranthene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	207-08-9	
Chrysene	ND	ug/L	0.50	1	08/06/12 11:05	08/08/12 04:01	218-01-9	
Dibenz(a,h)anthracene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	53-70-3	
Fluoranthene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	206-44-0	
Fluorene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	86-73-7	
Indeno(1,2,3-cd)pyrene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:01	193-39-5	
2-Methylnaphthalene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	91-57-6	
Naphthalene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	91-20-3	
Phenanthrene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	85-01-8	
Pyrene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:01	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	41	%.	26-106	1	08/06/12 11:05	08/08/12 04:01	321-60-8	
p-Terphenyl-d14 (S)	59	%.	16-111	1	08/06/12 11:05	08/08/12 04:01	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 00:11	71-43-2	
Ethylbenzene	ND	ug/L	5.0	1		08/13/12 00:11	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 00:11	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 00:11	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	102	%.	83-123	1		08/13/12 00:11	1868-53-7	
Toluene-d8 (S)	99	%.	81-114	1		08/13/12 00:11	2037-26-5	
4-Bromofluorobenzene (S)	99	%.	72-125	1		08/13/12 00:11	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	ND	mg/L	0.010	1		08/08/12 11:21	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: MW-102 **Lab ID: 5067059002** Collected: 08/01/12 17:20 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:55	7440-38-2	
Barium	**178**	ug/L	100	1	08/06/12 10:00	08/07/12 12:55	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 12:55	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:55	7440-47-3	
Iron	**2530**	ug/L	100	1	08/06/12 10:00	08/07/12 12:55	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:55	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:55	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 12:55	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 12:53	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**9.6**	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	83-32-9	
Acenaphthylene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	208-96-8	
Anthracene	**0.11**	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	120-12-7	
Benzo(a)anthracene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	56-55-3	
Benzo(a)pyrene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	50-32-8	
Benzo(b)fluoranthene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	205-99-2	
Benzo(g,h,i)perylene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	191-24-2	
Benzo(k)fluoranthene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	207-08-9	
Chrysene	ND	ug/L	0.50	1	08/06/12 11:05	08/08/12 04:19	218-01-9	
Dibenz(a,h)anthracene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	53-70-3	
Fluoranthene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	206-44-0	
Fluorene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	86-73-7	
Indeno(1,2,3-cd)pyrene	ND	ug/L	0.10	1	08/06/12 11:05	08/08/12 04:19	193-39-5	
2-Methylnaphthalene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	91-57-6	
Naphthalene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	91-20-3	
Phenanthrene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	85-01-8	
Pyrene	ND	ug/L	1.0	1	08/06/12 11:05	08/08/12 04:19	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	42	%.	26-106	1	08/06/12 11:05	08/08/12 04:19	321-60-8	
p-Terphenyl-d14 (S)	59	%.	16-111	1	08/06/12 11:05	08/08/12 04:19	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 00:43	71-43-2	
Ethylbenzene	ND	ug/L	5.0	1		08/13/12 00:43	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 00:43	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 00:43	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	104	%.	83-123	1		08/13/12 00:43	1868-53-7	
Toluene-d8 (S)	103	%.	81-114	1		08/13/12 00:43	2037-26-5	
4-Bromofluorobenzene (S)	98	%.	72-125	1		08/13/12 00:43	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	**0.038**	mg/L	0.010	1		08/08/12 11:22	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081

Pace Project No.: 5067059

Sample: MW-008 **Lab ID: 5067059003** Collected: 08/02/12 09:15 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:58	7440-38-2	
Barium	**256**	ug/L	100	1	08/06/12 10:00	08/07/12 12:58	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 12:58	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:58	7440-47-3	
Iron	**2750**	ug/L	100	1	08/06/12 10:00	08/07/12 12:58	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:58	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 12:58	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 12:58	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 12:55	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**17.8**	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	83-32-9	
Acenaphthylene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	208-96-8	
Anthracene	**0.12**	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	120-12-7	
Benzo(a)anthracene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	56-55-3	
Benzo(a)pyrene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	50-32-8	
Benzo(b)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	205-99-2	
Benzo(g,h,i)perylene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	191-24-2	
Benzo(k)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	207-08-9	
Chrysene	ND	ug/L	0.50	1	08/06/12 14:25	08/07/12 17:50	218-01-9	
Dibenz(a,h)anthracene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	53-70-3	
Fluoranthene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	206-44-0	
Fluorene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	86-73-7	
Indeno(1,2,3-cd)pyrene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 17:50	193-39-5	
2-Methylnaphthalene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	91-57-6	
Naphthalene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	91-20-3	
Phenanthrene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	85-01-8	
Pyrene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 17:50	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	48	%.	26-106	1	08/06/12 14:25	08/07/12 17:50	321-60-8	
p-Terphenyl-d14 (S)	63	%.	16-111	1	08/06/12 14:25	08/07/12 17:50	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 01:15	71-43-2	
Ethylbenzene	ND	ug/L	5.0	1		08/13/12 01:15	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 01:15	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 01:15	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	103	%.	83-123	1		08/13/12 01:15	1868-53-7	
Toluene-d8 (S)	101	%.	81-114	1		08/13/12 01:15	2037-26-5	
4-Bromofluorobenzene (S)	98	%.	72-125	1		08/13/12 01:15	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	**0.13**	mg/L	0.010	1		08/08/12 11:22	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: MW-101 | **Lab ID: 5067059004** | Collected: 08/02/12 11:35 | Received: 08/03/12 13:18 | Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:04	7440-38-2	
Barium	**208**	ug/L	100	1	08/06/12 10:00	08/07/12 13:04	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 13:04	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:04	7440-47-3	
Iron	**1150**	ug/L	100	1	08/06/12 10:00	08/07/12 13:04	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:04	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:04	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 13:04	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 12:57	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**47.9**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	83-32-9	
Acenaphthylene	**1.7**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	208-96-8	
Anthracene	**0.74**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	120-12-7	
Benzo(a)anthracene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	56-55-3	
Benzo(a)pyrene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	50-32-8	
Benzo(b)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	205-99-2	
Benzo(g,h,i)perylene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	191-24-2	
Benzo(k)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	207-08-9	
Chrysene	ND	ug/L	0.50	1	08/06/12 14:25	08/07/12 18:08	218-01-9	
Dibenz(a,h)anthracene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	53-70-3	
Fluoranthene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	206-44-0	
Fluorene	**3.0**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	86-73-7	
Indeno(1,2,3-cd)pyrene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:08	193-39-5	
2-Methylnaphthalene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	91-57-6	
Naphthalene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	91-20-3	
Phenanthrene	ND	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	85-01-8	
Pyrene	**1.0**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:08	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	49	%.	26-106	1	08/06/12 14:25	08/07/12 18:08	321-60-8	
p-Terphenyl-d14 (S)	62	%.	16-111	1	08/06/12 14:25	08/07/12 18:08	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 02:19	71-43-2	
Ethylbenzene	ND	ug/L	5.0	1		08/13/12 02:19	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 02:19	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 02:19	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	108	%.	83-123	1		08/13/12 02:19	1868-53-7	
Toluene-d8 (S)	100	%.	81-114	1		08/13/12 02:19	2037-26-5	
4-Bromofluorobenzene (S)	99	%.	72-125	1		08/13/12 02:19	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	ND	mg/L	0.010	1		08/08/12 11:23	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: MW-011 **Lab ID: 5067059005** Collected: 08/02/12 14:25 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:06	7440-38-2	
Barium	**195**	ug/L	100	1	08/06/12 10:00	08/07/12 13:06	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 13:06	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:06	7440-47-3	
Iron	**933**	ug/L	100	1	08/06/12 10:00	08/07/12 13:06	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:06	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:06	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 13:06	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 12:59	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**78.3**	ug/L	10.0	10	08/06/12 14:25	08/08/12 16:55	83-32-9	
Acenaphthylene	**3.3**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:26	208-96-8	
Anthracene	**6.3**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	120-12-7	
Benzo(a)anthracene	**0.36**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	56-55-3	
Benzo(a)pyrene	**0.12**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	50-32-8	
Benzo(b)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	205-99-2	
Benzo(g,h,i)perylene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	191-24-2	
Benzo(k)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	207-08-9	
Chrysene	ND	ug/L	0.50	1	08/06/12 14:25	08/07/12 18:26	218-01-9	
Dibenz(a,h)anthracene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	53-70-3	
Fluoranthene	**5.3**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:26	206-44-0	
Fluorene	**26.7**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:26	86-73-7	
Indeno(1,2,3-cd)pyrene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:26	193-39-5	
2-Methylnaphthalene	**6.3**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:26	91-57-6	
Naphthalene	**37.4**	ug/L	10.0	10	08/06/12 14:25	08/08/12 16:55	91-20-3	
Phenanthrene	**26.9**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:26	85-01-8	
Pyrene	**6.1**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:26	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	49	%.	26-106	1	08/06/12 14:25	08/07/12 18:26	321-60-8	
p-Terphenyl-d14 (S)	59	%.	16-111	1	08/06/12 14:25	08/07/12 18:26	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 02:51	71-43-2	
Ethylbenzene	**8.6**	ug/L	5.0	1		08/13/12 02:51	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 02:51	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 02:51	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	101	%.	83-123	1		08/13/12 02:51	1868-53-7	
Toluene-d8 (S)	102	%.	81-114	1		08/13/12 02:51	2037-26-5	
4-Bromofluorobenzene (S)	104	%.	72-125	1		08/13/12 02:51	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	ND	mg/L	0.010	1		08/08/12 11:24	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: MW-006 **Lab ID: 5067059006** Collected: 08/02/12 15:55 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:09	7440-38-2	
Barium	**160**	ug/L	100	1	08/06/12 10:00	08/07/12 13:09	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 13:09	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:09	7440-47-3	
Iron	**2050**	ug/L	100	1	08/06/12 10:00	08/07/12 13:09	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:09	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:09	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 13:09	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 13:01	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	ND	ug/L	50.0	50	08/06/12 14:25	08/08/12 15:43	83-32-9	
Acenaphthylene	**3.8**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:44	208-96-8	
Anthracene	**12.0**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	120-12-7	
Benzo(a)anthracene	**4.5**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	56-55-3	
Benzo(a)pyrene	**4.2**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	50-32-8	
Benzo(b)fluoranthene	**1.9**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	205-99-2	
Benzo(g,h,i)perylene	**2.3**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	191-24-2	
Benzo(k)fluoranthene	**2.6**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	207-08-9	
Chrysene	**4.5**	ug/L	0.50	1	08/06/12 14:25	08/07/12 18:44	218-01-9	
Dibenz(a,h)anthracene	**0.71**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	53-70-3	
Fluoranthene	**14.1**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:44	206-44-0	
Fluorene	**22.6**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:44	86-73-7	
Indeno(1,2,3-cd)pyrene	**1.5**	ug/L	0.10	1	08/06/12 14:25	08/07/12 18:44	193-39-5	
2-Methylnaphthalene	**43.3**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:44	91-57-6	
Naphthalene	**357**	ug/L	50.0	50	08/06/12 14:25	08/08/12 15:43	91-20-3	
Phenanthrene	**43.6**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:44	85-01-8	
Pyrene	**19.6**	ug/L	1.0	1	08/06/12 14:25	08/07/12 18:44	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	41	%.	26-106	1	08/06/12 14:25	08/07/12 18:44	321-60-8	
p-Terphenyl-d14 (S)	39	%.	16-111	1	08/06/12 14:25	08/07/12 18:44	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	**966**	ug/L	100	20		08/14/12 06:56	71-43-2	
Ethylbenzene	**741**	ug/L	100	20		08/14/12 06:56	100-41-4	
Toluene	**51.3**	ug/L	5.0	1		08/13/12 03:23	108-88-3	
Xylene (Total)	**411**	ug/L	10.0	1		08/13/12 03:23	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	110	%.	83-123	1		08/13/12 03:23	1868-53-7	
Toluene-d8 (S)	100	%.	81-114	1		08/13/12 03:23	2037-26-5	
4-Bromofluorobenzene (S)	98	%.	72-125	1		08/13/12 03:23	460-00-4	
Iron, Ferrous	Analytical Method: SM 3500-Fe D#4							
Iron, Ferrous	ND	mg/L	0.20	1		08/03/12 13:50		N2

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: MW-006 **Lab ID: 5067059006** Collected: 08/02/12 15:55 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	**2.6**	mg/L	0.10	10		08/08/12 11:37	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: DUP-01 | **Lab ID: 5067059007** | Collected: 08/02/12 08:00 | Received: 08/03/12 13:18 | Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:11	7440-38-2	
Barium	**197**	ug/L	100	1	08/06/12 10:00	08/07/12 13:11	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/06/12 10:00	08/07/12 13:11	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:11	7440-47-3	
Iron	**942**	ug/L	100	1	08/06/12 10:00	08/07/12 13:11	7439-89-6	
Lead	ND	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:11	7439-92-1	
Selenium	**11.2**	ug/L	10.0	1	08/06/12 10:00	08/07/12 13:11	7782-49-2	
Silver	ND	ug/L	50.0	1	08/06/12 10:00	08/07/12 13:11	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/14/12 11:31	08/15/12 13:03	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**77.5**	ug/L	10.0	10	08/06/12 14:25	08/08/12 17:13	83-32-9	
Acenaphthylene	**3.4**	ug/L	1.0	1	08/06/12 14:25	08/07/12 19:02	208-96-8	
Anthracene	**6.4**	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	120-12-7	
Benzo(a)anthracene	**0.44**	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	56-55-3	
Benzo(a)pyrene	**0.20**	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	50-32-8	
Benzo(b)fluoranthene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	205-99-2	
Benzo(g,h,i)perylene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	191-24-2	
Benzo(k)fluoranthene	**0.14**	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	207-08-9	
Chrysene	ND	ug/L	0.50	1	08/06/12 14:25	08/07/12 19:02	218-01-9	
Dibenz(a,h)anthracene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	53-70-3	
Fluoranthene	**5.7**	ug/L	1.0	1	08/06/12 14:25	08/07/12 19:02	206-44-0	
Fluorene	**27.5**	ug/L	1.0	1	08/06/12 14:25	08/07/12 19:02	86-73-7	
Indeno(1,2,3-cd)pyrene	ND	ug/L	0.10	1	08/06/12 14:25	08/07/12 19:02	193-39-5	
2-Methylnaphthalene	**6.4**	ug/L	1.0	1	08/06/12 14:25	08/07/12 19:02	91-57-6	
Naphthalene	**37.2**	ug/L	10.0	10	08/06/12 14:25	08/08/12 17:13	91-20-3	
Phenanthrene	**27.3**	ug/L	1.0	1	08/06/12 14:25	08/07/12 19:02	85-01-8	
Pyrene	**6.5**	ug/L	1.0	1	08/06/12 14:25	08/07/12 19:02	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	47	%.	26-106	1	08/06/12 14:25	08/07/12 19:02	321-60-8	
p-Terphenyl-d14 (S)	56	%.	16-111	1	08/06/12 14:25	08/07/12 19:02	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 03:55	71-43-2	
Ethylbenzene	**9.7**	ug/L	5.0	1		08/13/12 03:55	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 03:55	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 03:55	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	102	%.	83-123	1		08/13/12 03:55	1868-53-7	
Toluene-d8 (S)	98	%.	81-114	1		08/13/12 03:55	2037-26-5	
4-Bromofluorobenzene (S)	98	%.	72-125	1		08/13/12 03:55	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	ND	mg/L	0.010	1		08/08/12 11:30	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Sample: TBK-01 **Lab ID: 5067059008** Collected: 08/02/12 08:00 Received: 08/03/12 13:18 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	ND	ug/L	5.0	1		08/13/12 04:27	71-43-2	
Ethylbenzene	ND	ug/L	5.0	1		08/13/12 04:27	100-41-4	
Toluene	ND	ug/L	5.0	1		08/13/12 04:27	108-88-3	
Xylene (Total)	ND	ug/L	10.0	1		08/13/12 04:27	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	100	%.	83-123	1		08/13/12 04:27	1868-53-7	
Toluene-d8 (S)	100	%.	81-114	1		08/13/12 04:27	2037-26-5	
4-Bromofluorobenzene (S)	100	%.	72-125	1		08/13/12 04:27	460-00-4	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: MERP/4047 Analysis Method: EPA 7470
QC Batch Method: EPA 7470 Analysis Description: 7470 Mercury
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

METHOD BLANK: 781079 Matrix: Water
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mercury	ug/L	ND	2.0	08/15/12 12:38	

LABORATORY CONTROL SAMPLE: 781080

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mercury	ug/L	5	4.8	96	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 781081 781082

Parameter	Units	5067059001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mercury	ug/L	ND	5	5	4.7	4.8	94	95	75-125	.6	20	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: MPRP/9604 | Analysis Method: EPA 6010
QC Batch Method: EPA 3010 | Analysis Description: 6010 MET
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

METHOD BLANK: 776963 | Matrix: Water
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Arsenic	ug/L	ND	10.0	08/07/12 12:38	
Barium	ug/L	ND	100	08/07/12 12:38	
Cadmium	ug/L	ND	5.0	08/07/12 12:38	
Chromium	ug/L	ND	10.0	08/07/12 12:38	
Iron	ug/L	ND	100	08/07/12 12:38	
Lead	ug/L	ND	10.0	08/07/12 12:38	
Selenium	ug/L	ND	10.0	08/07/12 12:38	
Silver	ug/L	ND	50.0	08/07/12 12:38	

LABORATORY CONTROL SAMPLE: 776964

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Arsenic	ug/L	1000	992	99	80-120	
Barium	ug/L	1000	997	100	80-120	
Cadmium	ug/L	1000	994	99	80-120	
Chromium	ug/L	1000	976	98	80-120	
Iron	ug/L	10000	10100	101	80-120	
Lead	ug/L	1000	984	98	80-120	
Selenium	ug/L	1000	1010	101	80-120	
Silver	ug/L	500	489	98	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776965 776966

Parameter	Units	5066907002 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Arsenic	ug/L	ND	1000	1000	1020	1020	102	102	75-125	.6	20	
Barium	ug/L	ND	1000	1000	1050	1040	99	98	75-125	.4	20	
Cadmium	ug/L	ND	1000	1000	1010	1000	101	100	75-125	.4	20	
Chromium	ug/L	ND	1000	1000	956	952	95	95	75-125	.4	20	
Iron	ug/L	178	10000	10000	10000	10000	99	99	75-125	0	20	
Lead	ug/L	ND	1000	1000	970	966	97	97	75-125	.5	20	
Selenium	ug/L	ND	1000	1000	1030	1020	103	101	75-125	1	20	
Silver	ug/L	ND	500	500	498	496	99	99	75-125	.3	20	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081

Pace Project No.: 5067059

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776967 776968

Parameter	Units	5066984018 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Arsenic	ug/L	33.3	1000	1000	1020	1030	99	100	75-125	1	20	
Barium	ug/L	3330	1000	1000	4310	4360	98	104	75-125	1	20	
Cadmium	ug/L	ND	1000	1000	981	984	98	98	75-125	.3	20	
Chromium	ug/L	62.6	1000	1000	974	972	91	91	75-125	.2	20	
Iron	ug/L	95600	10000	10000	116000	118000	201	224	75-125	2	20	P6
Lead	ug/L	255	1000	1000	1160	1180	91	92	75-125	.9	20	
Selenium	ug/L	ND	1000	1000	985	996	98	99	75-125	1	20	
Silver	ug/L	ND	500	500	491	493	98	99	75-125	.4	20	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: MSV/44825 | Analysis Method: EPA 8260
QC Batch Method: EPA 8260 | Analysis Description: 8260 MSV UST-WATER
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007, 5067059008

METHOD BLANK: 780420 Matrix: Water
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007, 5067059008

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Benzene	ug/L	ND	5.0	08/12/12 23:39	
Ethylbenzene	ug/L	ND	5.0	08/12/12 23:39	
Toluene	ug/L	ND	5.0	08/12/12 23:39	
Xylene (Total)	ug/L	ND	10.0	08/12/12 23:39	
4-Bromofluorobenzene (S)	%.	98	72-125	08/12/12 23:39	
Dibromofluoromethane (S)	%.	101	83-123	08/12/12 23:39	
Toluene-d8 (S)	%.	98	81-114	08/12/12 23:39	

LABORATORY CONTROL SAMPLE: 780421

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Benzene	ug/L	50	46.4	93	76-123	
Ethylbenzene	ug/L	50	46.2	92	75-120	
Toluene	ug/L	50	45.4	91	72-124	
Xylene (Total)	ug/L	150	140	94	72-126	
4-Bromofluorobenzene (S)	%.			100	72-125	
Dibromofluoromethane (S)	%.			102	83-123	
Toluene-d8 (S)	%.			99	81-114	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 780422 780423

Parameter	Units	5067420002 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Benzene	ug/L	ND	50	50	46.8	47.3	94	95	52-134	.9	20	
Ethylbenzene	ug/L	ND	50	50	47.0	51.0	94	102	29-132	8	20	
Toluene	ug/L	ND	50	50	47.1	48.5	94	97	42-130	3	20	
Xylene (Total)	ug/L	ND	150	150	144	150	96	100	29-131	4	20	
4-Bromofluorobenzene (S)	%.						100	102	72-125		20	
Dibromofluoromethane (S)	%.						108	109	83-123		20	
Toluene-d8 (S)	%.						99	99	81-114		20	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: OEXT/30349
Analysis Method: EPA 8270 by SIM LVE
QC Batch Method: EPA 3510
Analysis Description: 8270 Water PAH LV by SIM MSSV
Associated Lab Samples: 5067059001, 5067059002

METHOD BLANK: 777012
Matrix: Water
Associated Lab Samples: 5067059001, 5067059002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
2-Methylnaphthalene	ug/L	ND	1.0	08/07/12 22:01	
Acenaphthene	ug/L	ND	1.0	08/07/12 22:01	
Acenaphthylene	ug/L	ND	1.0	08/07/12 22:01	
Anthracene	ug/L	ND	0.10	08/07/12 22:01	
Benzo(a)anthracene	ug/L	ND	0.10	08/07/12 22:01	
Benzo(a)pyrene	ug/L	ND	0.10	08/07/12 22:01	
Benzo(b)fluoranthene	ug/L	ND	0.10	08/07/12 22:01	
Benzo(g,h,i)perylene	ug/L	ND	0.10	08/07/12 22:01	
Benzo(k)fluoranthene	ug/L	ND	0.10	08/07/12 22:01	
Chrysene	ug/L	ND	0.50	08/07/12 22:01	
Dibenz(a,h)anthracene	ug/L	ND	0.10	08/07/12 22:01	
Fluoranthene	ug/L	ND	1.0	08/07/12 22:01	
Fluorene	ug/L	ND	1.0	08/07/12 22:01	
Indeno(1,2,3-cd)pyrene	ug/L	ND	0.10	08/07/12 22:01	
Naphthalene	ug/L	ND	1.0	08/07/12 22:01	
Phenanthrene	ug/L	ND	1.0	08/07/12 22:01	
Pyrene	ug/L	ND	1.0	08/07/12 22:01	
2-Fluorobiphenyl (S)	%.	39	26-106	08/07/12 22:01	
p-Terphenyl-d14 (S)	%.	65	16-111	08/07/12 22:01	

LABORATORY CONTROL SAMPLE: 777013

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
2-Methylnaphthalene	ug/L	10	3.7	37	24-104	
Acenaphthene	ug/L	10	4.3	43	31-108	
Acenaphthylene	ug/L	10	4.6	46	33-111	
Anthracene	ug/L	10	5.4	54	45-120	
Benzo(a)anthracene	ug/L	10	6.4	64	51-119	
Benzo(a)pyrene	ug/L	10	7.0	70	52-124	
Benzo(b)fluoranthene	ug/L	10	6.9	69	51-122	
Benzo(g,h,i)perylene	ug/L	10	7.1	71	48-112	
Benzo(k)fluoranthene	ug/L	10	7.3	73	53-123	
Chrysene	ug/L	10	7.1	71	54-118	
Dibenz(a,h)anthracene	ug/L	10	6.8	68	49-114	
Fluoranthene	ug/L	10	6.5	65	52-122	
Fluorene	ug/L	10	5.0	50	38-113	
Indeno(1,2,3-cd)pyrene	ug/L	10	6.8	68	49-114	
Naphthalene	ug/L	10	3.7	37	27-103	
Phenanthrene	ug/L	10	5.6	56	43-112	
Pyrene	ug/L	10	6.4	64	51-120	
2-Fluorobiphenyl (S)	%.			36	26-106	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

LABORATORY CONTROL SAMPLE: 777013

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
p-Terphenyl-d14 (S)	%.			59	16-111	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 777014 777015

Parameter	Units	5067101010 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
2-Methylnaphthalene	ug/L	ND	10	10	3.6	4.1	36	41	10-130	13	20	
Acenaphthene	ug/L	ND	10	10	4.0	4.5	40	45	32-102	11	20	
Acenaphthylene	ug/L	ND	10	10	4.3	4.8	43	48	25-118	9	20	
Anthracene	ug/L	ND	10	10	4.8	5.6	48	56	46-116	16	20	
Benzo(a)anthracene	ug/L	ND	10	10	5.3	6.2	53	62	31-102	16	20	
Benzo(a)pyrene	ug/L	ND	10	10	4.3	5.0	43	50	10-93	16	20	
Benzo(b)fluoranthene	ug/L	ND	10	10	4.5	5.2	45	52	11-93	14	20	
Benzo(g,h,i)perylene	ug/L	ND	10	10	3.5	3.9	35	39	10-77	11	20	
Benzo(k)fluoranthene	ug/L	ND	10	10	4.7	5.5	47	55	12-91	15	20	
Chrysene	ug/L	ND	10	10	5.9	6.9	59	69	34-99	17	20	
Dibenz(a,h)anthracene	ug/L	ND	10	10	3.5	4.0	35	40	10-79	14	20	
Fluoranthene	ug/L	ND	10	10	5.6	6.5	56	65	48-116	15	20	
Fluorene	ug/L	ND	10	10	4.6	5.0	46	50	41-108	10	20	
Indeno(1,2,3-cd)pyrene	ug/L	ND	10	10	3.4	3.8	34	38	10-79	12	20	
Naphthalene	ug/L	ND	10	10	3.6	4.1	36	41	23-107	13	20	
Phenanthrene	ug/L	ND	10	10	5.1	5.8	51	58	46-107	12	20	
Pyrene	ug/L	ND	10	10	5.5	6.4	55	64	46-115	14	20	
2-Fluorobiphenyl (S)	%.						35	39	26-106		20	
p-Terphenyl-d14 (S)	%.						50	58	16-111		20	

QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: OEXT/30352 Analysis Method: EPA 8270 by SIM LVE
QC Batch Method: EPA 3510 Analysis Description: 8270 Water PAH LV by SIM MSSV
Associated Lab Samples: 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

METHOD BLANK: 777028 Matrix: Water
Associated Lab Samples: 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
2-Methylnaphthalene	ug/L	ND	1.0	08/07/12 14:50	
Acenaphthene	ug/L	ND	1.0	08/07/12 14:50	
Acenaphthylene	ug/L	ND	1.0	08/07/12 14:50	
Anthracene	ug/L	ND	0.10	08/07/12 14:50	
Benzo(a)anthracene	ug/L	ND	0.10	08/07/12 14:50	
Benzo(a)pyrene	ug/L	ND	0.10	08/07/12 14:50	
Benzo(b)fluoranthene	ug/L	ND	0.10	08/07/12 14:50	
Benzo(g,h,i)perylene	ug/L	ND	0.10	08/07/12 14:50	
Benzo(k)fluoranthene	ug/L	ND	0.10	08/07/12 14:50	
Chrysene	ug/L	ND	0.50	08/07/12 14:50	
Dibenz(a,h)anthracene	ug/L	ND	0.10	08/07/12 14:50	
Fluoranthene	ug/L	ND	1.0	08/07/12 14:50	
Fluorene	ug/L	ND	1.0	08/07/12 14:50	
Indeno(1,2,3-cd)pyrene	ug/L	ND	0.10	08/07/12 14:50	
Naphthalene	ug/L	ND	1.0	08/07/12 14:50	
Phenanthrene	ug/L	ND	1.0	08/07/12 14:50	
Pyrene	ug/L	ND	1.0	08/07/12 14:50	
2-Fluorobiphenyl (S)	%.	49	26-106	08/07/12 14:50	
p-Terphenyl-d14 (S)	%.	71	16-111	08/07/12 14:50	

LABORATORY CONTROL SAMPLE: 777029

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
2-Methylnaphthalene	ug/L	10	4.3	43	24-104	
Acenaphthene	ug/L	10	5.2	52	31-108	
Acenaphthylene	ug/L	10	5.3	53	33-111	
Anthracene	ug/L	10	6.2	62	45-120	
Benzo(a)anthracene	ug/L	10	6.5	65	51-119	
Benzo(a)pyrene	ug/L	10	7.0	70	52-124	
Benzo(b)fluoranthene	ug/L	10	6.9	69	51-122	
Benzo(g,h,i)perylene	ug/L	10	7.4	74	48-112	
Benzo(k)fluoranthene	ug/L	10	7.5	75	53-123	
Chrysene	ug/L	10	7.2	72	54-118	
Dibenz(a,h)anthracene	ug/L	10	7.0	70	49-114	
Fluoranthene	ug/L	10	7.0	70	52-122	
Fluorene	ug/L	10	6.0	60	38-113	
Indeno(1,2,3-cd)pyrene	ug/L	10	7.1	71	49-114	
Naphthalene	ug/L	10	4.3	43	27-103	
Phenanthrene	ug/L	10	6.3	63	43-112	
Pyrene	ug/L	10	6.8	68	51-120	
2-Fluorobiphenyl (S)	%.			43	26-106	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

LABORATORY CONTROL SAMPLE: 777029

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
p-Terphenyl-d14 (S)	%.			63	16-111	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 777030 777031

Parameter	Units	5067099003 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
2-Methylnaphthalene	ug/L	ND	10	10	5.6	5.4	55	54	10-130	3	20	
Acenaphthene	ug/L	ND	10	10	6.3	6.2	63	62	32-102	2	20	
Acenaphthylene	ug/L	ND	10	10	6.3	6.2	63	62	25-118	2	20	
Anthracene	ug/L	ND	10	10	6.8	6.8	68	68	46-116	.1	20	
Benzo(a)anthracene	ug/L	ND	10	10	6.8	7.0	68	70	31-102	2	20	
Benzo(a)pyrene	ug/L	ND	10	10	6.0	6.3	60	63	10-93	4	20	
Benzo(b)fluoranthene	ug/L	ND	10	10	6.1	6.5	61	65	11-93	7	20	
Benzo(g,h,i)perylene	ug/L	ND	10	10	3.1	4.1	31	41	10-77	29	20	R1
Benzo(k)fluoranthene	ug/L	ND	10	10	6.6	6.7	66	67	12-91	.3	20	
Chrysene	ug/L	ND	10	10	7.7	7.7	77	77	34-99	.7	20	
Dibenz(a,h)anthracene	ug/L	ND	10	10	2.9	3.8	29	38	10-79	25	20	R1
Fluoranthene	ug/L	ND	10	10	7.7	7.9	77	79	48-116	2	20	
Fluorene	ug/L	ND	10	10	6.8	6.7	68	67	41-108	2	20	
Indeno(1,2,3-cd)pyrene	ug/L	ND	10	10	3.1	3.9	31	39	10-79	22	20	R1
Naphthalene	ug/L	ND	10	10	5.4	5.4	54	54	23-107	1	20	
Phenanthrene	ug/L	ND	10	10	7.1	7.1	69	69	46-107	.6	20	
Pyrene	ug/L	ND	10	10	7.4	7.5	73	74	46-115	1	20	
2-Fluorobiphenyl (S)	%.						50	50	26-106		20	
p-Terphenyl-d14 (S)	%.						64	63	16-111		20	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: WET/9823 | Analysis Method: SM 3500-Fe D#4
QC Batch Method: SM 3500-Fe D#4 | Analysis Description: Iron, Ferrous
Associated Lab Samples: 5067059006

METHOD BLANK: 776496 | Matrix: Water
Associated Lab Samples: 5067059006

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Iron, Ferrous	mg/L	ND	0.20	08/03/12 13:50	N2

LABORATORY CONTROL SAMPLE: 776497

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Iron, Ferrous	mg/L	1	1.0	101	90-110	N2

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776498 | 776499

Parameter	Units	5067059006 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Iron, Ferrous	mg/L	ND	1	1	1.2	1.2	105	106	90-110	.8	20	N2

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

QC Batch: WETA/8425 — Analysis Method: EPA 335.4
QC Batch Method: EPA 335.4 — Analysis Description: 335.4 Cyanide, Total
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

METHOD BLANK: 776991 — Matrix: Water
Associated Lab Samples: 5067059001, 5067059002, 5067059003, 5067059004, 5067059005, 5067059006, 5067059007

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Cyanide	mg/L	ND	0.010	08/08/12 11:03	

LABORATORY CONTROL SAMPLE: 776992

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Cyanide	mg/L	.2	0.22	108	90-110	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776993 776994

Parameter	Units	5066385002 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Cyanide	mg/L	ND	.2	.2	0.20	0.21	102	106	90-110	4	20	

MATRIX SPIKE SAMPLE: 776995

Parameter	Units	5067059007 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Cyanide	mg/L	ND	.2	0.21	102	90-110	

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QUALIFIERS

Project:	Richmond former MGP 60194081
Pace Project No.:	5067059

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.

PRL - Pace Reporting 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.

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

TNI - The NELAC Institute.

ANALYTE QUALIFIERS

N2	The lab does not hold TNI accreditation for this parameter.
P6	Matrix spike recovery was outside laboratory control limits due to a parent sample concentration notably higher than the spike level.
R1	RPD value was outside control limits.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Richmond former MGP 60194081
Pace Project No.: 5067059

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
5067059001	**MW-010**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059002	**MW-102**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059003	**MW-008**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059004	**MW-101**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059005	**MW-011**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059006	**MW-006**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059007	**DUP-01**	EPA 3010	MPRP/9604	EPA 6010	ICP/9836
5067059001	**MW-010**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059002	**MW-102**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059003	**MW-008**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059004	**MW-101**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059005	**MW-011**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059006	**MW-006**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059007	**DUP-01**	EPA 7470	MERP/4047	EPA 7470	MERC/4018
5067059001	**MW-010**	EPA 3510	OEXT/30349	EPA 8270 by SIM LVE	MSSV/10674
5067059002	**MW-102**	EPA 3510	OEXT/30349	EPA 8270 by SIM LVE	MSSV/10674
5067059003	**MW-008**	EPA 3510	OEXT/30352	EPA 8270 by SIM LVE	MSSV/10673
5067059004	**MW-101**	EPA 3510	OEXT/30352	EPA 8270 by SIM LVE	MSSV/10673
5067059005	**MW-011**	EPA 3510	OEXT/30352	EPA 8270 by SIM LVE	MSSV/10673
5067059006	**MW-006**	EPA 3510	OEXT/30352	EPA 8270 by SIM LVE	MSSV/10673
5067059007	**DUP-01**	EPA 3510	OEXT/30352	EPA 8270 by SIM LVE	MSSV/10673
5067059001	**MW-010**	EPA 8260	MSV/44825		
5067059002	**MW-102**	EPA 8260	MSV/44825		
5067059003	**MW-008**	EPA 8260	MSV/44825		
5067059004	**MW-101**	EPA 8260	MSV/44825		
5067059005	**MW-011**	EPA 8260	MSV/44825		
5067059006	**MW-006**	EPA 8260	MSV/44825		
5067059007	**DUP-01**	EPA 8260	MSV/44825		
5067059008	**TBK-01**	EPA 8260	MSV/44825		
5067059006	**MW-006**	SM 3500-Fe D#4	WET/9823		
5067059001	**MW-010**	EPA 335.4	WETA/8425		
5067059002	**MW-102**	EPA 335.4	WETA/8425		
5067059003	**MW-008**	EPA 335.4	WETA/8425		
5067059004	**MW-101**	EPA 335.4	WETA/8425		
5067059005	**MW-011**	EPA 335.4	WETA/8425		
5067059006	**MW-006**	EPA 335.4	WETA/8425		
5067059007	**DUP-01**	EPA 335.4	WETA/8425		

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CHAIN-OF-CUSTODY / Analytical Request Document

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

√ MS

Page: 1 of 1

1552159

Section A Required Client Information:

- Company: AECOM
- Address: 8902 Vincennes Circle, Indianapolis, IN 46268
- Email To: nathan.conniff@aecom.com
- Phone: 317-735-3021 Fax: 317-735-3040
- Requested Due Date/TAT: Standard

Section B Required Project Information:

- Report To: Nathan Conniff
- Copy To: Jeffrey Nelson jeffrey.nelson@aecom.com
- Purchase Order No.:
- Project Name: Richmond former MGP
- Project Number: 60194081

Section C Invoice Information:

- Attention: Nathan Conniff
- Company Name: AECOM
- Address: 8902 Vincennes Circle
- Pace Quote Reference:
- Pace Project Manager: Lyle Cable
- Pace Profile #:

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER ☐ UST ☐ RCRA ☒ OTHER IDEM Brownfields

Site Location STATE: IN

Section D Required Client Information

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

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

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	TIME	COMPOSITE END/GRAB DATE	TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	BTEX	PAHs + 2-MN	Total CN	RCRA Metals + Fe	Ferrous Iron	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
																								5067059
1	~~MW-00~~ MW-010	WT	G	8/1/12	1440				7	2		1	3	1				X	X	X	X			-001
2	MW-102	WT	G	8/1/12	1720				7	2		1	3	1				X	X	X	X			-002
3	MW-008	WT	G	8/2/12	0915				7	2		1	3	1				X	X	X	X			-003
4	~~MW-102~~ MW-101	WT	G	8/2/12	1135				7	2		1	3	1				X	X	X	X			-004
5	MW-011	WT	G	8/2/12	1425				7	2		1	3	1				X	X	X	X			-005
6	MW-006	WT	G	8/2/12	1555				7	3		1	3	1				X	X	X	X	X		-006
7	DUP-01	WT	G	8/2/12	—				7	2		1	3	1				X	X	X	X			-007
8	TBK-01	WT	G	8/2/12	—				3				3					X						-008
9																								
10																								
11																								
12																								

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
	[signature] AECOM	8/3/12	1318	K Chandler Pace	8/3/12	1318	~~1.3~~ 1.1	Y	N	Y

SAMPLE CONDITIONS

W/Client del ORIGINAL

SAMPLER NAME AND SIGNATURE

- PRINT Name of SAMPLER: Nathan Conniff
- SIGNATURE of SAMPLER: [signature]
- DATE Signed (MM/DD/YY): 8/3/12

*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

Sample Condition Upon Receipt

Pace Analytical

Client Name: AECOM Project # 5067059

Courier: ☐ Fed Ex ☐ UPS ☐ USPS ☒ Client ☐ Commercial ☐ Pace Other

Tracking #:

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

Packing Material: ☐ Bubble Wrap ☒ Bubble Bags ☐ None ☒ Other Ice/PLC

Date/Time 5035A kits placed in freezer

Thermometer Used 1 2 3 4 6 A B C D E

Type of Ice: Wet Blue None ☒ Samples on ice, cooling process has begun

Cooler Temperature (Corrected, if applicable) 1.3, 1.4 C

Ice Visible in Sample Containers: ☐ yes ☒ no

Temp should be above freezing to 6°C

Date and Initials of person examining contents: 8/3/12 KG

				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.
Short Hold Time Analysis (<72hr):	☒Yes	☐No	☐N/A	5. took Ferrous Iron to wetchem
Rush Turn Around Time Requested:	☐Yes	☒No	☐N/A	6.
Containers Intact:	☒Yes	☐No	☐N/A	7.
Sample Labels match COC: -Includes date/time/ID/Analysis	☒Yes	☐No	☐N/A	8.
All containers needing acid/base pres. have been checked? exceptions: VOA, coliform, TOC, O&G	☒Yes	☐No	☐N/A	9. (Circle) HNO3 H2SO4 NaOH HCl
All containers needing preservation are found to be in compliance with EPA recommendation.	☒Yes	☐No	☐N/A	
Headspace in VOA Vials (>6mm):	☐Yes	☒No	☐N/A	10.
Trip Blank Present:	☒Yes	☐No	☐N/A	11.
Trip Blank Custody Seals Present	☒Yes	☐No	☐N/A	
Project Manager Review				
Samples Arrived within Hold Time:	☒Yes	☐No	☐N/A	12.
Sufficient Volume:	☒Yes	☐No	☐N/A	13.
Correct Containers Used:	☒Yes	☐No	☐N/A	14.

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

Person Contacted: ______ Date/Time: ______

Comments/ Resolution: ______

Project Manager Review: [signature] **Date:** 8-3-12

Sample Container Count

CLIENT: AECOM

COC PAGE 1 of 1

COC ID# 1552159

Project # 5067059

Sample Line Item	DG9H	AG1U	WGFU	AG0U	R 4/6	BP2N	BP2U	BP2S	BP3N	BP3U	BP3S	AG3S	AG1H	BP3C	Comments
1	3			2					1					1	
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

Container Codes

DG9H	40mL HCL amber voa vial	AG0U	100mL unpreserved amber glass	BP1N	1 liter HNO3 plastic	DG9P	40mL TSP amber vial
AG1U	1liter unpreserved amber glass	AG1H	1 liter HCL amber glass	BP1S	1 liter H2SO4 plastic	DG9S	40mL H2SO4 amber vial
WGFU	4oz clear soil jar	AG1S	1 liter H2SO4 amber glass	BP1U	1 liter unpreserved plastic	DG9T	40mL Na Thio amber vial
R	terra core kit	AG1T	1 liter Na Thiosulfate amber gl	BP1Z	1 liter NaOH, Zn, Ac	DG9U	40mL unpreserved amber vial
BP2N	500mL HNO3 plastic	AG2N	500mL HNO3 amber glass	BP2A	500mL NaOH, Asc Acid plastic	I	Wipe/Swab
BP2U	500mL unpreserved plastic	AG2S	500mL H2SO4 amber glass	BP2O	500mL NaOH plastic	JGFU	4oz unpreserved amber wide
BP2S	500mL H2SO4 plastic	AG2U	500mL unpreserved amber gla	BP2Z	500mL NaOH, Zn Ac	U	Summa Can
BP3N	250mL HNO3 plastic	AG3U	250mL unpreserved amber gla	AF	Air Filter	VG9H	40mL HCL clear vial
BP3U	250mL unpreserved plastic	BG1H	1 liter HCL clear glass	BP3C	250mL NaOH plastic	VG9T	40mL Na Thio. clear vial
BP3S	250mL H2SO4 plastic	BG1S	1 liter H2SO4 clear glass	BP3Z	250mL NaOH, Zn Ac plastic	VG9U	40mL unpreserved clear vial
AG3S	250mL H2SO4 glass amber	BG1T	1 liter Na Thiosulfate clear gla	C	Air Cassettes	VSG	Headspace septa vial & HCL
AG1S	1 liter H2SO4 amber glass	BG1U	1 liter unpreserved glass	DG9B	40mL Na Bisulfate amber vial	WGFX	4oz wide jar w/hexane wipe
BP1U	1 liter unpreserved plastic	BP1A	1 liter NaOH, Asc Acid plastic	DG9M	40mL MeOH clear vial	ZPLC	Ziploc Bag

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August 17, 2012

Nathan Conniff
AECOM
8902 Vincennes Circle
Indianapolis, IN 46268

RE: Project: Richmond former MGP 60194081
Pace Project No.: 5067080

Dear Nathan Conniff:

Enclosed are the analytical results for sample(s) received by the laboratory on August 03, 2012. 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.

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

Sincerely,

Lyle Cable

lyle.cable@pacelabs.com
Project Manager

Enclosures

cc: Jeffrey Nelson

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CERTIFICATIONS

Project:	Richmond former MGP 60194081
Pace Project No.:	5067080

Green Bay Certification IDs

1241 Bellevue Street, Green Bay, WI 54302
Florida/NELAP Certification #: E87948
Illinois Certification #: 200050
Kentucky Certification #: 82
Louisiana Certification #: 04168
Minnesota Certification #: 055-999-334
New York Certification #: 11888
North Carolina Certification #: 503
North Dakota Certification #: R-150
South Carolina Certification #: 83006001
US Dept of Agriculture #: S-76505
Wisconsin Certification #: 405132750

Indiana Certification IDs

7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 200074
Indiana Certification #: C-49-06
Kansas Certification #: E-10247
Kentucky Certification #: 0042
Louisiana/NELAC Certification #: 04076
Ohio VAP Certification #: CL0065
Pennsylvania Certification #: 68-04991
West Virginia Certification #: 330

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SAMPLE SUMMARY

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

Lab ID	Sample ID	Matrix	Date Collected	Date Received
5067080001	**SB-12-02 (24-26)**	Solid	07/31/12 14:24	08/03/12 13:18

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SAMPLE ANALYTE COUNT

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
5067080001	**SB-12-02 (24-26)**	EPA 8270 by SIM	CEM	19	PASI-I
		EPA 8260	GRM	7	PASI-I
		ASTM D2974-87	DAE	1	PASI-I
		Walkley Black	TJJ	1	PASI-G

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ANALYTICAL RESULTS

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

Sample: SB-12-02 (24-26) **Lab ID: 5067080001** Collected: 07/31/12 14:24 Received: 08/03/12 13:18 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
8270 MSSV PAH by SIM	Analytical Method: EPA 8270 by SIM Preparation Method: EPA 3546							
Acenaphthene	**7620**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	83-32-9	
Acenaphthylene	**11700**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	208-96-8	1d
Anthracene	**13200**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	120-12-7	
Benzo(a)anthracene	**9790**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	56-55-3	
Benzo(a)pyrene	**7080**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	50-32-8	
Benzo(b)fluoranthene	**4770**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	205-99-2	
Benzo(g,h,i)perylene	**2980**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	191-24-2	
Benzo(k)fluoranthene	**5790**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	207-08-9	
Chrysene	**8960**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	218-01-9	
Dibenz(a,h)anthracene	**1700**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	53-70-3	
Fluoranthene	**19600**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	206-44-0	
Fluorene	**13200**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	86-73-7	
Indeno(1,2,3-cd)pyrene	**2780**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	193-39-5	
2-Methylnaphthalene	**32600**	ug/kg	1210	200	08/06/12 10:34	08/10/12 05:47	91-57-6	
Naphthalene	**96200**	ug/kg	1210	200	08/06/12 10:34	08/10/12 05:47	91-20-3	
Phenanthrene	**43400**	ug/kg	1210	200	08/06/12 10:34	08/10/12 05:47	85-01-8	
Pyrene	**17700**	ug/kg	60.4	10	08/06/12 10:34	08/09/12 04:02	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	61	%.	46-109	10	08/06/12 10:34	08/09/12 04:02	321-60-8	
p-Terphenyl-d14 (S)	68	%.	43-107	10	08/06/12 10:34	08/09/12 04:02	1718-51-0	
8260/5035A Volatile Organics	Analytical Method: EPA 8260							
Benzene	**4220**	ug/kg	398	100		08/08/12 10:12	71-43-2	
Ethylbenzene	**18800**	ug/kg	398	100		08/08/12 10:12	100-41-4	
Toluene	**8270**	ug/kg	398	100		08/08/12 10:12	108-88-3	
Xylene (Total)	**37700**	ug/kg	796	100		08/08/12 10:12	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	97	%.	71-125	100		08/08/12 10:12	1868-53-7	
Toluene-d8 (S)	98	%.	76-124	100		08/08/12 10:12	2037-26-5	
4-Bromofluorobenzene (S)	99	%.	67-134	100		08/08/12 10:12	460-00-4	
Percent Moisture	Analytical Method: ASTM D2974-87							
Percent Moisture	**17.2**	%	0.10	1		08/13/12 17:55		
Organic Carbon Walkley Black	Analytical Method: Walkley Black							
Total Organic Carbon	**6820**	mg/kg	1140	1	08/15/12 11:10	08/15/12 14:02	7440-44-0	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

QC Batch: MSV/44688
Analysis Method: EPA 8260
QC Batch Method: EPA 8260
Analysis Description: 8260 MSV 5035A Volatile Organics
Associated Lab Samples: 5067080001

METHOD BLANK: 778090 Matrix: Solid

Associated Lab Samples: 5067080001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Benzene	ug/kg	ND	5.0	08/08/12 00:59	
Ethylbenzene	ug/kg	ND	5.0	08/08/12 00:59	
Toluene	ug/kg	ND	5.0	08/08/12 00:59	
Xylene (Total)	ug/kg	ND	10.0	08/08/12 00:59	
4-Bromofluorobenzene (S)	%.	92	67-134	08/08/12 00:59	
Dibromofluoromethane (S)	%.	97	71-125	08/08/12 00:59	
Toluene-d8 (S)	%.	98	76-124	08/08/12 00:59	

LABORATORY CONTROL SAMPLE: 778091

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Benzene	ug/kg	50	44.9	90	73-115	
Ethylbenzene	ug/kg	50	47.7	95	73-120	
Toluene	ug/kg	50	44.2	88	69-115	
Xylene (Total)	ug/kg	150	145	97	69-117	
4-Bromofluorobenzene (S)	%.			94	67-134	
Dibromofluoromethane (S)	%.			102	71-125	
Toluene-d8 (S)	%.			98	76-124	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

QC Batch: OEXT/30344 — Analysis Method: EPA 8270 by SIM
QC Batch Method: EPA 3546 — Analysis Description: 8270 MSSV PAH by SIM
Associated Lab Samples: 5067080001

METHOD BLANK: 776969 — Matrix: Solid
Associated Lab Samples: 5067080001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
2-Methylnaphthalene	ug/kg	ND	5.0	08/09/12 03:08	
Acenaphthene	ug/kg	ND	5.0	08/09/12 03:08	
Acenaphthylene	ug/kg	ND	5.0	08/09/12 03:08	
Anthracene	ug/kg	ND	5.0	08/09/12 03:08	
Benzo(a)anthracene	ug/kg	ND	5.0	08/09/12 03:08	
Benzo(a)pyrene	ug/kg	ND	5.0	08/09/12 03:08	
Benzo(b)fluoranthene	ug/kg	ND	5.0	08/09/12 03:08	
Benzo(g,h,i)perylene	ug/kg	ND	5.0	08/09/12 03:08	
Benzo(k)fluoranthene	ug/kg	ND	5.0	08/09/12 03:08	
Chrysene	ug/kg	ND	5.0	08/09/12 03:08	
Dibenz(a,h)anthracene	ug/kg	ND	5.0	08/09/12 03:08	
Fluoranthene	ug/kg	ND	5.0	08/09/12 03:08	
Fluorene	ug/kg	ND	5.0	08/09/12 03:08	
Indeno(1,2,3-cd)pyrene	ug/kg	ND	5.0	08/09/12 03:08	
Naphthalene	ug/kg	ND	5.0	08/09/12 03:08	
Phenanthrene	ug/kg	ND	5.0	08/09/12 03:08	
Pyrene	ug/kg	ND	5.0	08/09/12 03:08	
2-Fluorobiphenyl (S)	%.	84	46-109	08/09/12 03:08	
p-Terphenyl-d14 (S)	%.	86	43-107	08/09/12 03:08	

LABORATORY CONTROL SAMPLE: 776970

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
2-Methylnaphthalene	ug/kg	333	241	72	49-116	
Acenaphthene	ug/kg	333	250	75	52-114	
Acenaphthylene	ug/kg	333	251	75	52-119	
Anthracene	ug/kg	333	268	81	55-124	
Benzo(a)anthracene	ug/kg	333	251	75	52-122	
Benzo(a)pyrene	ug/kg	333	266	80	56-131	
Benzo(b)fluoranthene	ug/kg	333	237	71	54-125	
Benzo(g,h,i)perylene	ug/kg	333	267	80	55-122	
Benzo(k)fluoranthene	ug/kg	333	299	90	55-128	
Chrysene	ug/kg	333	283	85	56-118	
Dibenz(a,h)anthracene	ug/kg	333	262	79	56-125	
Fluoranthene	ug/kg	333	264	79	55-125	
Fluorene	ug/kg	333	253	76	54-120	
Indeno(1,2,3-cd)pyrene	ug/kg	333	256	77	56-124	
Naphthalene	ug/kg	333	245	74	52-112	
Phenanthrene	ug/kg	333	258	77	53-116	
Pyrene	ug/kg	333	263	79	55-120	
2-Fluorobiphenyl (S)	%.			79	46-109	

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

LABORATORY CONTROL SAMPLE: 776970

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
p-Terphenyl-d14 (S)	%.			81	43-107	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776971 776972

Parameter	Units	5067078022 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
2-Methylnaphthalene	ug/kg	ND	412	412	189	258	46	62	43-106	31	20	R1
Acenaphthene	ug/kg	ND	412	412	183	250	44	61	46-101	31	20	M0,R1
Acenaphthylene	ug/kg	ND	412	412	174	243	42	59	47-105	33	20	M0,R1
Anthracene	ug/kg	ND	412	412	200	246	48	60	39-112	21	20	R1
Benzo(a)anthracene	ug/kg	ND	412	412	216	259	52	63	36-105	18	20	
Benzo(a)pyrene	ug/kg	ND	412	412	207	250	50	60	34-113	19	20	
Benzo(b)fluoranthene	ug/kg	ND	412	412	200	258	48	62	33-111	25	20	R1
Benzo(g,h,i)perylene	ug/kg	ND	412	412	202	246	48	59	26-109	20	20	
Benzo(k)fluoranthene	ug/kg	ND	412	412	231	267	55	64	31-116	14	20	
Chrysene	ug/kg	ND	412	412	230	276	56	67	34-109	18	20	
Dibenz(a,h)anthracene	ug/kg	ND	412	412	203	250	49	61	32-111	21	20	R1
Fluoranthene	ug/kg	ND	412	412	228	270	55	65	33-117	17	20	
Fluorene	ug/kg	ND	412	412	189	261	46	63	44-107	32	20	R1
Indeno(1,2,3-cd)pyrene	ug/kg	ND	412	412	200	241	48	58	27-113	18	20	
Naphthalene	ug/kg	ND	412	412	190	269	46	65	45-106	35	20	R1
Phenanthrene	ug/kg	ND	412	412	213	274	52	66	42-103	25	20	R1
Pyrene	ug/kg	ND	412	412	227	272	55	66	36-111	18	20	
2-Fluorobiphenyl (S)	%.						47	65	46-109		20	R1
p-Terphenyl-d14 (S)	%.						56	67	43-107		20	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776973 776974

Parameter	Units	5067091010 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
2-Methylnaphthalene	ug/kg	1730	395	395	3900	1650	549	-20	43-106	81	20	E,M0,R1
Acenaphthene	ug/kg	24.5	395	395	322	157	75	33	46-101	69	20	M0,R1
Acenaphthylene	ug/kg	ND	395	395	328	160	83	41	47-105	69	20	M0,R1
Anthracene	ug/kg	ND	395	395	352	150	89	38	39-112	81	20	M0,R1
Benzo(a)anthracene	ug/kg	6.7	395	395	299	129	74	31	36-105	79	20	M0,R1
Benzo(a)pyrene	ug/kg	ND	395	395	288	124	73	31	34-113	80	20	M0,R1
Benzo(b)fluoranthene	ug/kg	ND	395	395	307	132	78	33	33-111	80	20	R1
Benzo(g,h,i)perylene	ug/kg	3.1J	395	395	279	121	70	30	26-109	79	20	R1
Benzo(k)fluoranthene	ug/kg	ND	395	395	276	116	70	29	31-116	82	20	R1
Chrysene	ug/kg	45.3	395	395	394	164	88	30	34-109	82	20	M0,R1
Dibenz(a,h)anthracene	ug/kg	ND	395	395	275	117	70	30	32-111	80	20	R1
Fluoranthene	ug/kg	17.8	395	395	337	145	81	32	33-117	80	20	M0,R1
Fluorene	ug/kg	132	395	395	518	247	98	29	44-107	71	20	M0,R1
Indeno(1,2,3-cd)pyrene	ug/kg	ND	395	395	270	117	68	30	27-113	79	20	R1

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 776973 776974

Parameter	Units	5067091010 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Naphthalene	ug/kg	926	395	395	2060	949	287	6	45-106	74	20	E,M0, R1
Phenanthrene	ug/kg	319	395	395	1000	408	173	23	42-103	84	20	M0,R1
Pyrene	ug/kg	20.7	395	395	338	142	80	31	36-111	82	20	M0,R1
2-Fluorobiphenyl (S)	%.						71	34	46-109		20	R1,S0
p-Terphenyl-d14 (S)	%.						84	33	43-107		20	R1,S0

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

QC Batch: PMST/7351
QC Batch Method: ASTM D2974-87
Analysis Method: ASTM D2974-87
Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 5067080001

SAMPLE DUPLICATE: 780112

Parameter	Units	5067185001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	13.3	13.3	.6	5	

SAMPLE DUPLICATE: 780113

Parameter	Units	5067292005 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	21.4	22.7	6	5	R1

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QUALITY CONTROL DATA

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

QC Batch: WETA/13651 — Analysis Method: Walkley Black
QC Batch Method: Walkley Black — Analysis Description: Organic Carbon
Associated Lab Samples: 5067080001

METHOD BLANK: 655203 — Matrix: Solid
Associated Lab Samples: 5067080001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Organic Carbon	mg/kg	ND	400	08/15/12 14:02	

LABORATORY CONTROL SAMPLE: 655204

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/kg	16000	16700	104	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 655205 655206

Parameter	Units	5067147001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Total Organic Carbon	mg/kg	9170	98800	98800	112000	112000	104	104	80-120	0	20	

QUALIFIERS

Project:	Richmond former MGP 60194081
Pace Project No.:	5067080

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.

PRL - Pace Reporting 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.

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

TNI - The NELAC Institute.

LABORATORIES

PASI-G	Pace Analytical Services - Green Bay
PASI-I	Pace Analytical Services - Indianapolis

BATCH QUALIFIERS

Batch: WETA/13663

[WB]	Results reported on dry weight basis per cited method.

ANALYTE QUALIFIERS

1d	Due to the extract's physical characteristics, the analysis was performed at dilution. CEM 08/09/12
E	Analyte concentration exceeded the calibration range. The reported result is estimated.
M0	Matrix spike recovery and/or matrix spike duplicate recovery was outside laboratory control limits.
R1	RPD value was outside control limits.
S0	Surrogate recovery outside laboratory control limits.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Richmond former MGP 60194081
Pace Project No.: 5067080

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
5067080001	**SB-12-02 (24-26)**	EPA 3546	OEXT/30344	EPA 8270 by SIM	MSSV/10672
5067080001	**SB-12-02 (24-26)**	EPA 8260	MSV/44688		
5067080001	**SB-12-02 (24-26)**	ASTM D2974-87	PMST/7351		
5067080001	**SB-12-02 (24-26)**	Walkley Black	WETA/13651	Walkley Black	WETA/13663

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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

1552157

Section A Required Client Information:
- Company: AECOM
- Address: 8902 Vincennes Circle, Ste D, Indianapolis, IN 46268
- Email To: nathan.conniff@aecom.com
- Phone: 317-735-3021 Fax: 317-735-3040
- Requested Due Date/TAT: Standard

Section B Required Project Information:
- Report To: Nathan Conniff
- Copy To: Jeffrey Nelson, jeffrey.nelson@aecom.com
- Purchase Order No.: Com
- Project Name: Richmond former MGP
- Project Number: 60194081

Section C Invoice Information:
- Attention: Nathan Conniff
- Company Name: AECOM
- Address: 8902 Vincennes Circle
- Pace Quote Reference:
- Pace Project Manager: Lyle Cable
- Pace Profile #:

REGULATORY AGENCY
- ☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
- ☐ UST ☐ RCRA X OTHER Brownfields

Site Location STATE: IN

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

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE	SAMPLE TYPE (G=GRAB C=COMP)	Composite Start DATE	Composite Start TIME	Composite End/Grab DATE	Composite End/Grab TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other DI	BTEX	PAHs+2-MN	TOC	Residual Chlorine (Y/N)	Pace Project No./Lab I.D. 5067080
1	SB-12-02 (24-26)	SL	G	8/13/12	1424				6	3						1	2	X	X	X		-001
2																						
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						
11																						
12																						

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
	[signature] AECOM	8/3/12	1318	[signature] Pace	8.3.12	1318	1.3	Y	N	Y

WIChertdel ORIGINAL

SAMPLER NAME AND SIGNATURE
- PRINT Name of SAMPLER: Nathan Conniff
- SIGNATURE of SAMPLER: [signature]
- DATE Signed (MM/DD/YY): 8/3/12

*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

Sample Condition Upon Receipt

Pace Analytical

Client Name: AECOM Project # 5067080

Courier: ☐ Fed Ex ☐ UPS ☐ USPS ☒ Client ☐ Commercial ☐ Pace Other

Tracking #:

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

Date/Time 5035A kits placed in freezer: 8/3/12 @ 1339

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☐ None ☒ Other Ice Pack / Foam block

Thermometer Used 1 2 3 4 6 A B C D Type of Ice: (Wet) Blue None ☒ Samples on ice, cooling process has begun

Cooler Temperature 1.3 C
(Corrected, if applicable)

Ice Visible in Sample Containers: ☐ yes ☒ no

Temp should be above freezing to 6°C

Date and Initials of person examining contents: 8/3/12 Kelly

				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.
Short Hold Time Analysis (<72hr):	☐Yes	☒No	☐N/A	5. TCLP
Rush Turn Around Time Requested:	☐Yes	☒No	☐N/A	6.
Containers Intact:	☒Yes	☐No	☐N/A	7.
Sample Labels match COC: -Includes date/time/ID/Analysis	☒Yes	☐No	☐N/A	8.
All containers needing acid/base pres. have been checked? exceptions: VOA, coliform, TOC, O&G	☐Yes	☐No	☒N/A	9. (Circle) HNO3 H2SO4 NaOH HCl
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes	☐No	☒N/A	
Headspace in VOA Vials (>6mm)	☐Yes	☒No	☐N/A	10.
Trip Blank Present:	☐Yes	☒No	☐N/A	11.
Trip Blank Custody Seals Present	☐Yes	☐No	☒N/A	
Project Manager Review				
Samples Arrived within Hold Time:	☒Yes	☐No	☐N/A	12.
Sufficient Volume:	☒Yes	☐No	☐N/A	13.
Correct Containers Used:	☒Yes	☐No	☐N/A	14.

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

Person Contacted: ______________ Date/Time: ______________

Comments/ Resolution: ______________

Project Manager Review: [signature] **Date:** 8-3-12

Form F-IN-Q290-rev.04, 28Apr2011

Sample Container Count

CLIENT: AECOM

COC PAGE 1 of 1

COC ID# 1550157

Project # 5067080

Sample Line Item	DG9H	AG1U	WGFU	AG0U	R 4/6	BP2N	BP2U	BP2S	BP3N	BP3U	BP3S	AG3S	AG1H			Comments
1			2		4											
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

Container Codes

DG9H	40mL HCL amber voa vial	AG0U	100mL unpreserved amber glass	BP1N	1 liter HNO3 plastic	DG9P	40mL TSP amber vial
AG1U	1liter unpreserved amber glass	AG1H	1 liter HCL amber glass	BP1S	1 liter H2SO4 plastic	DG9S	40mL H2SO4 amber vial
WGFU	4oz clear soil jar	AG1S	1 liter H2SO4 amber glass	BP1U	1 liter unpreserved plastic	DG9T	40mL Na Thio amber vial
R	terra core kit	AG1T	1 liter Na Thiosulfate amber gl	BP1Z	1 liter NaOH, Zn, Ac	DG9U	40mL unpreserved **amber** vial
BP2N	500mL HNO3 plastic	AG2N	500mL HNO3 amber glass	BP2A	500mL NaOH, Asc Acid plastic	I	Wipe/Swab
BP2U	500mL unpreserved plastic	AG2S	500mL H2SO4 amber glass	BP2O	500mL NaOH plastic	JGFU	4oz unpreserved amber wide
BP2S	500mL H2SO4 plastic	AG2U	500mL unpreserved amber gla	BP2Z	500mL NaOH, Zn Ac	U	Summa Can
BP3N	250mL HNO3 plastic	AG3U	250mL unpreserved amber gla	AF	Air Filter	VG9H	40mL HCL clear vial
BP3U	250mL unpreserved plastic	BG1H	1 liter HCL clear glass	BP3C	250mL NaOH plastic	VG9T	40mL Na Thio. clear vial
BP3S	250mL H2SO4 plastic	BG1S	1 liter H2SO4 clear glass	BP3Z	250mL NaOH, Zn Ac plastic	VG9U	40mL unpreserved **clear** vial
AG3S	250mL H2SO4 glass amber	BG1T	1 liter Na Thiosulfate clear gla	C	Air Cassettes	VSG	Headspace septa vial & HCL
AG1S	1 liter H2SO4 amber glass	BG1U	1 liter unpreserved glass	DG9B	40mL Na Bisulfate amber vial	WGFX	4oz wide jar w/hexane wipe
BP1U	1 liter unpreserved plastic	BP1A	1 liter NaOH, Asc Acid plastic	DG9M	40mL MeOH clear vial	ZPLC	Ziploc Bag

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August 23, 2012

Nathan Conniff
AECOM
8902 Vincennes Circle
Indianapolis, IN 46268

RE: Project: Richmond MGP
Pace Project No.: 5067787

Dear Nathan Conniff:

Enclosed are the analytical results for sample(s) received by the laboratory on August 18, 2012. 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.

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

Sincerely,

Lyle Cable

lyle.cable@pacelabs.com
Project Manager

Enclosures

cc: Jeffrey Nelson

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CERTIFICATIONS

Project: Richmond MGP
Pace Project No.: 5067787

Indiana Certification IDs
7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 200074
Indiana Certification #: C-49-06
Kansas Certification #: E-10247
Kentucky Certification #: 0042
Louisiana/NELAC Certification #: 04076
Ohio VAP Certification #: CL0065
Pennsylvania Certification #: 68-04991
West Virginia Certification #: 330

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SAMPLE SUMMARY

Project: Richmond MGP
Pace Project No.: 5067787

Lab ID	Sample ID	Matrix	Date Collected	Date Received
5067787001	**MW-015**	Water	08/17/12 18:45	08/18/12 12:07
5067787002	**MW-012D**	Water	08/17/12 16:55	08/18/12 12:07

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SAMPLE ANALYTE COUNT

Project: Richmond MGP
Pace Project No.: 5067787

Lab ID	Sample ID	Method	Analysts	Analytes Reported
5067787001	**MW-015**	EPA 6010	LLB	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	KMP	7
		EPA 335.4	ILP	1
5067787002	**MW-012D**	EPA 6010	LLB	8
		EPA 7470	LLB	1
		EPA 8270 by SIM LVE	CEM	19
		EPA 8260	KMP	7
		EPA 335.4	ILP	1

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ANALYTICAL RESULTS

Project: Richmond MGP
Pace Project No.: 5067787

Sample: MW-015 | **Lab ID: 5067787001** | Collected: 08/17/12 18:45 | Received: 08/18/12 12:07 | Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:01	7440-38-2	
Barium	**242**	ug/L	100	1	08/20/12 03:00	08/20/12 16:01	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/20/12 03:00	08/20/12 16:01	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:01	7440-47-3	
Iron	**2390**	ug/L	100	1	08/20/12 03:00	08/20/12 16:01	7439-89-6	
Lead	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:01	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:01	7782-49-2	
Silver	ND	ug/L	50.0	1	08/20/12 03:00	08/20/12 16:01	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/20/12 10:22	08/21/12 12:43	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**249**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:22	83-32-9	
Acenaphthylene	**21.1**	ug/L	1.0	1	08/20/12 10:40	08/22/12 19:50	208-96-8	
Anthracene	**30.9**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	120-12-7	
Benzo(a)anthracene	**10.5**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	56-55-3	
Benzo(a)pyrene	**8.3**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	50-32-8	
Benzo(b)fluoranthene	**3.6**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	205-99-2	
Benzo(g,h,i)perylene	**3.3**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	191-24-2	
Benzo(k)fluoranthene	**4.3**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	207-08-9	
Chrysene	**10.0**	ug/L	0.50	1	08/20/12 10:40	08/22/12 19:50	218-01-9	
Dibenz(a,h)anthracene	**1.3**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	53-70-3	
Fluoranthene	**27.4**	ug/L	1.0	1	08/20/12 10:40	08/22/12 19:50	206-44-0	
Fluorene	**70.3**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:22	86-73-7	
Indeno(1,2,3-cd)pyrene	**2.5**	ug/L	0.10	1	08/20/12 10:40	08/22/12 19:50	193-39-5	
2-Methylnaphthalene	**34.0**	ug/L	1.0	1	08/20/12 10:40	08/22/12 19:50	91-57-6	
Naphthalene	**193**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:22	91-20-3	
Phenanthrene	**122**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:22	85-01-8	
Pyrene	**40.4**	ug/L	1.0	1	08/20/12 10:40	08/22/12 19:50	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	68	%.	26-106	1	08/20/12 10:40	08/22/12 19:50	321-60-8	
p-Terphenyl-d14 (S)	91	%.	16-111	1	08/20/12 10:40	08/22/12 19:50	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	**40.0**	ug/L	5.0	1		08/20/12 20:34	71-43-2	
Ethylbenzene	**51.0**	ug/L	5.0	1		08/20/12 20:34	100-41-4	
Toluene	ND	ug/L	5.0	1		08/20/12 20:34	108-88-3	
Xylene (Total)	**18.1**	ug/L	10.0	1		08/20/12 20:34	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	101	%.	83-123	1		08/20/12 20:34	1868-53-7	
Toluene-d8 (S)	99	%.	81-114	1		08/20/12 20:34	2037-26-5	
4-Bromofluorobenzene (S)	100	%.	72-125	1		08/20/12 20:34	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	**0.23**	mg/L	0.010	1		08/20/12 14:57	57-12-5	

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ANALYTICAL RESULTS

Project: Richmond MGP
Pace Project No.: 5067787

Sample: MW-012D **Lab ID: 5067787002** Collected: 08/17/12 16:55 Received: 08/18/12 12:07 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3010							
Arsenic	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:21	7440-38-2	
Barium	**244**	ug/L	100	1	08/20/12 03:00	08/20/12 16:21	7440-39-3	
Cadmium	ND	ug/L	5.0	1	08/20/12 03:00	08/20/12 16:21	7440-43-9	
Chromium	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:21	7440-47-3	
Iron	**1700**	ug/L	100	1	08/20/12 03:00	08/20/12 16:21	7439-89-6	
Lead	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:21	7439-92-1	
Selenium	ND	ug/L	10.0	1	08/20/12 03:00	08/20/12 16:21	7782-49-2	
Silver	ND	ug/L	50.0	1	08/20/12 03:00	08/20/12 16:21	7440-22-4	
7470 Mercury	Analytical Method: EPA 7470 Preparation Method: EPA 7470							
Mercury	ND	ug/L	2.0	1	08/20/12 10:22	08/21/12 12:49	7439-97-6	
8270 MSSV PAHLV	Analytical Method: EPA 8270 by SIM LVE Preparation Method: EPA 3510							
Acenaphthene	**65.1**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:40	83-32-9	
Acenaphthylene	**27.0**	ug/L	1.0	1	08/20/12 10:40	08/22/12 20:08	208-96-8	
Anthracene	**20.5**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	120-12-7	
Benzo(a)anthracene	**6.2**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	56-55-3	
Benzo(a)pyrene	**5.2**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	50-32-8	
Benzo(b)fluoranthene	**2.3**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	205-99-2	
Benzo(g,h,i)perylene	**2.4**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	191-24-2	
Benzo(k)fluoranthene	**3.0**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	207-08-9	
Chrysene	**5.9**	ug/L	0.50	1	08/20/12 10:40	08/22/12 20:08	218-01-9	
Dibenz(a,h)anthracene	**0.69**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	53-70-3	
Fluoranthene	**19.7**	ug/L	1.0	1	08/20/12 10:40	08/22/12 20:08	206-44-0	
Fluorene	**47.8**	ug/L	1.0	1	08/20/12 10:40	08/22/12 20:08	86-73-7	
Indeno(1,2,3-cd)pyrene	**1.7**	ug/L	0.10	1	08/20/12 10:40	08/22/12 20:08	193-39-5	
2-Methylnaphthalene	**45.6**	ug/L	1.0	1	08/20/12 10:40	08/22/12 20:08	91-57-6	
Naphthalene	**261**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:40	91-20-3	
Phenanthrene	**38.5**	ug/L	10.0	10	08/20/12 10:40	08/23/12 09:40	85-01-8	
Pyrene	**30.1**	ug/L	1.0	1	08/20/12 10:40	08/22/12 20:08	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	72	%.	26-106	1	08/20/12 10:40	08/22/12 20:08	321-60-8	
p-Terphenyl-d14 (S)	94	%.	16-111	1	08/20/12 10:40	08/22/12 20:08	1718-51-0	
8260 MSV UST	Analytical Method: EPA 8260							
Benzene	**73.2**	ug/L	5.0	1		08/20/12 21:07	71-43-2	
Ethylbenzene	**99.1**	ug/L	5.0	1		08/20/12 21:07	100-41-4	
Toluene	ND	ug/L	5.0	1		08/20/12 21:07	108-88-3	
Xylene (Total)	**28.1**	ug/L	10.0	1		08/20/12 21:07	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	99	%.	83-123	1		08/20/12 21:07	1868-53-7	
Toluene-d8 (S)	99	%.	81-114	1		08/20/12 21:07	2037-26-5	
4-Bromofluorobenzene (S)	100	%.	72-125	1		08/20/12 21:07	460-00-4	
335.4 Cyanide, Total	Analytical Method: EPA 335.4							
Cyanide	**0.14**	mg/L	0.010	1		08/20/12 14:59	57-12-5	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067787

QC Batch: MERP/4058 | Analysis Method: EPA 7470
QC Batch Method: EPA 7470 | Analysis Description: 7470 Mercury
Associated Lab Samples: 5067787001, 5067787002

METHOD BLANK: 784235 | Matrix: Water
Associated Lab Samples: 5067787001, 5067787002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mercury	ug/L	ND	2.0	08/21/12 12:39	

LABORATORY CONTROL SAMPLE: 784236

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mercury	ug/L	5	4.8	96	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 784237 784238

Parameter	Units	5067787001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mercury	ug/L	ND	5	5	5.1	4.8	102	96	75-125	6	20	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067787

QC Batch: MPRP/9690
Analysis Method: EPA 6010
QC Batch Method: EPA 3010
Analysis Description: 6010 MET
Associated Lab Samples: 5067787001, 5067787002

METHOD BLANK: 784187 Matrix: Water
Associated Lab Samples: 5067787001, 5067787002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Arsenic	ug/L	ND	10.0	08/20/12 15:54	
Barium	ug/L	ND	100	08/20/12 15:54	
Cadmium	ug/L	ND	5.0	08/20/12 15:54	
Chromium	ug/L	ND	10.0	08/20/12 15:54	
Iron	ug/L	ND	100	08/20/12 15:54	
Lead	ug/L	ND	10.0	08/20/12 15:54	
Selenium	ug/L	ND	10.0	08/20/12 15:54	
Silver	ug/L	ND	50.0	08/20/12 15:54	

LABORATORY CONTROL SAMPLE: 784188

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Arsenic	ug/L	1000	984	98	80-120	
Barium	ug/L	1000	978	98	80-120	
Cadmium	ug/L	1000	968	97	80-120	
Chromium	ug/L	1000	958	96	80-120	
Iron	ug/L	10000	9800	98	80-120	
Lead	ug/L	1000	960	96	80-120	
Selenium	ug/L	1000	977	98	80-120	
Silver	ug/L	500	481	96	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 784189 784190

Parameter	Units	5067708019 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Arsenic	ug/L	21.4	1000	1000	1010	1010	99	99	75-125	.3	20	
Barium	ug/L	160	1000	1000	1130	1130	97	97	75-125	.3	20	
Cadmium	ug/L	ND	1000	1000	970	968	97	97	75-125	.2	20	
Chromium	ug/L	ND	1000	1000	943	941	93	93	75-125	.2	20	
Iron	ug/L	14200	10000	10000	23800	23600	96	94	75-125	.9	20	
Lead	ug/L	ND	1000	1000	924	923	92	92	75-125	.05	20	
Selenium	ug/L	ND	1000	1000	970	970	97	97	75-125	.01	20	
Silver	ug/L	ND	500	500	484	484	97	97	75-125	.02	20	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067787

QC Batch: MSV/45018 Analysis Method: EPA 8260
QC Batch Method: EPA 8260 Analysis Description: 8260 MSV UST-WATER
Associated Lab Samples: 5067787001, 5067787002

METHOD BLANK: 784442 Matrix: Water
Associated Lab Samples: 5067787001, 5067787002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Benzene	ug/L	ND	5.0	08/20/12 20:01	
Ethylbenzene	ug/L	ND	5.0	08/20/12 20:01	
Toluene	ug/L	ND	5.0	08/20/12 20:01	
Xylene (Total)	ug/L	ND	10.0	08/20/12 20:01	
4-Bromofluorobenzene (S)	%.	95	72-125	08/20/12 20:01	
Dibromofluoromethane (S)	%.	107	83-123	08/20/12 20:01	
Toluene-d8 (S)	%.	99	81-114	08/20/12 20:01	

LABORATORY CONTROL SAMPLE: 784443

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Benzene	ug/L	50	48.3	97	76-123	
Ethylbenzene	ug/L	50	46.7	93	75-120	
Toluene	ug/L	50	47.4	95	72-124	
Xylene (Total)	ug/L	150	144	96	72-126	
4-Bromofluorobenzene (S)	%.			104	72-125	
Dibromofluoromethane (S)	%.			92	83-123	
Toluene-d8 (S)	%.			99	81-114	

MATRIX SPIKE SAMPLE: 784444

Parameter	Units	5067736002 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Benzene	ug/L	ND	50	43.7	87	52-134	
Ethylbenzene	ug/L	ND	50	42.4	85	29-132	
Toluene	ug/L	ND	50	43.8	87	42-130	
Xylene (Total)	ug/L	ND	150	129	86	29-131	
4-Bromofluorobenzene (S)	%.				101	72-125	
Dibromofluoromethane (S)	%.				94	83-123	
Toluene-d8 (S)	%.				101	81-114	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067787

QC Batch: OEXT/30481 — Analysis Method: EPA 8270 by SIM LVE
QC Batch Method: EPA 3510 — Analysis Description: 8270 Water PAH LV by SIM MSSV
Associated Lab Samples: 5067787001, 5067787002

METHOD BLANK: 784239 — Matrix: Water
Associated Lab Samples: 5067787001, 5067787002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
2-Methylnaphthalene	ug/L	ND	1.0	08/22/12 19:14	
Acenaphthene	ug/L	ND	1.0	08/22/12 19:14	
Acenaphthylene	ug/L	ND	1.0	08/22/12 19:14	
Anthracene	ug/L	ND	0.10	08/22/12 19:14	
Benzo(a)anthracene	ug/L	ND	0.10	08/22/12 19:14	
Benzo(a)pyrene	ug/L	ND	0.10	08/22/12 19:14	
Benzo(b)fluoranthene	ug/L	ND	0.10	08/22/12 19:14	
Benzo(g,h,i)perylene	ug/L	ND	0.10	08/22/12 19:14	
Benzo(k)fluoranthene	ug/L	ND	0.10	08/22/12 19:14	
Chrysene	ug/L	ND	0.50	08/22/12 19:14	
Dibenz(a,h)anthracene	ug/L	ND	0.10	08/22/12 19:14	
Fluoranthene	ug/L	ND	1.0	08/22/12 19:14	
Fluorene	ug/L	ND	1.0	08/22/12 19:14	
Indeno(1,2,3-cd)pyrene	ug/L	ND	0.10	08/22/12 19:14	
Naphthalene	ug/L	ND	1.0	08/22/12 19:14	
Phenanthrene	ug/L	ND	1.0	08/22/12 19:14	
Pyrene	ug/L	ND	1.0	08/22/12 19:14	
2-Fluorobiphenyl (S)	%.	73	26-106	08/22/12 19:14	
p-Terphenyl-d14 (S)	%.	108	16-111	08/22/12 19:14	

LABORATORY CONTROL SAMPLE: 784240

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
2-Methylnaphthalene	ug/L	10	6.7	67	24-104	
Acenaphthene	ug/L	10	7.5	75	31-108	
Acenaphthylene	ug/L	10	7.9	79	33-111	
Anthracene	ug/L	10	9.3	93	45-120	
Benzo(a)anthracene	ug/L	10	10	100	51-119	
Benzo(a)pyrene	ug/L	10	10.5	105	52-124	
Benzo(b)fluoranthene	ug/L	10	10.7	107	51-122	
Benzo(g,h,i)perylene	ug/L	10	10.4	104	48-112	
Benzo(k)fluoranthene	ug/L	10	10.2	102	53-123	
Chrysene	ug/L	10	10.0	100	54-118	
Dibenz(a,h)anthracene	ug/L	10	10.4	104	49-114	
Fluoranthene	ug/L	10	9.9	99	52-122	
Fluorene	ug/L	10	8.5	85	38-113	
Indeno(1,2,3-cd)pyrene	ug/L	10	10.5	105	49-114	
Naphthalene	ug/L	10	6.7	67	27-103	
Phenanthrene	ug/L	10	8.8	88	43-112	
Pyrene	ug/L	10	9.7	97	51-120	
2-Fluorobiphenyl (S)	%.			76	26-106	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067787

LABORATORY CONTROL SAMPLE: 784240

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
p-Terphenyl-d14 (S)	%.			100	16-111	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067787

QC Batch: WETA/8482 — Analysis Method: EPA 335.4
QC Batch Method: EPA 335.4 — Analysis Description: 335.4 Cyanide, Total
Associated Lab Samples: 5067787001, 5067787002

METHOD BLANK: 784210 — Matrix: Water
Associated Lab Samples: 5067787001, 5067787002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Cyanide	mg/L	ND	0.010	08/20/12 14:51	

LABORATORY CONTROL SAMPLE: 784211

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Cyanide	mg/L	.2	0.21	107	90-110	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 784212 784213

Parameter	Units	5067787001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Cyanide	mg/L	0.23	.2	.2	0.44	0.44	104	103	90-110	.4	20	

MATRIX SPIKE SAMPLE: 784214

Parameter	Units	5067718020 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Cyanide	mg/L	ND	.2	0.21	104	90-110	

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QUALIFIERS

Project:	Richmond MGP
Pace Project No.:	5067787

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.

PRL - Pace Reporting 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.

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

TNI - The NELAC Institute.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Richmond MGP
Pace Project No.: 5067787

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
5067787001	**MW-015**	EPA 3010	MPRP/9690	EPA 6010	ICP/9932
5067787002	**MW-012D**	EPA 3010	MPRP/9690	EPA 6010	ICP/9932
5067787001	**MW-015**	EPA 7470	MERP/4058	EPA 7470	MERC/4039
5067787002	**MW-012D**	EPA 7470	MERP/4058	EPA 7470	MERC/4039
5067787001	**MW-015**	EPA 3510	OEXT/30481	EPA 8270 by SIM LVE	MSSV/10766
5067787002	**MW-012D**	EPA 3510	OEXT/30481	EPA 8270 by SIM LVE	MSSV/10766
5067787001	**MW-015**	EPA 8260	MSV/45018		
5067787002	**MW-012D**	EPA 8260	MSV/45018		
5067787001	**MW-015**	EPA 335.4	WETA/8482		
5067787002	**MW-012D**	EPA 335.4	WETA/8482		

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CHAIN-OF-CUSTODY / Analytical Request Document

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

Page: of

1603043

Section A Required Client Information:

Company:	AECOM
Address:	9902 VINCENNEC CIR SUITE D
Email To:	Nathan.Conniff@aecom.com
Phone:	317-735-3021
Fax:	317-735-3046
Requested Due Date/TAT:	RUSH 2 DAY

Section B Required Project Information:

Report To:	NATHAN CONNIFF
Copy To:	
Purchase Order No.:	
Project Name:	RICHMOND MGP
Project Number:	

Section C Invoice Information:

Attention:	
Company Name:	
Address:	
Pace Quote Reference:	
Pace Project Manager:	LYLE CABLE
Pace Profile #:	

REGULATORY AGENCY

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

Site Location STATE: IN

Requested Analysis Filtered (Y/N)

5067787

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	TIME	COMPOSITE END/GRAB DATE	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	BTEX (N)	PAH + 2MN (N)	TOTAL RCRA METALS (N)	TOTAL CN (N)	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	MW-015	WT	G	8-17-12	1845	—	—		7	2		1	3	1					X	X	X	X	N	-001
2	MW-012D	WT	G	8-17-12	1655	—	—		7	2		1	3	1					X	X	X	X	N	-002
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
	[signature] AECOM	8/17/12	2100	[signature] / Pace	8/18/12	1207	1.9	Y	Y	Y

SAMPLER NAME AND SIGNATURE Ray McKibben [signature]

PRINT Name of SAMPLER:

SIGNATURE of SAMPLER: DATE Signed (MM/DD/YY): 8/17/12

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

ORIGINAL

WI/Fedex

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

Sample Condition Upon Receipt

Pace Analytical™ Client Name: Arcom Project # 5067787

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

Tracking #: 8010 5428 5150

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

Date/Time 5035A kits placed in freezer

Packing Material: ☑ Bubble Wrap ☐ Bubble Bags ☐ None ☐ Other

Thermometer Used 1 2 3 4 6 A B C D (E) **Type of Ice:** (Wet) Blue None ☐ Samples on ice, cooling process has begun

Cooler Temperature 1.9°C **Ice Visible in Sample Containers:** ☐ yes ☑ no

(Corrected, if applicable)

Temp should be above freezing to 6°C

Date and Initials of person examining contents: LO 8/18/12

				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.
Short Hold Time Analysis (<72hr):	☐ Yes	☑ No	☐ N/A	5.
Rush Turn Around Time Requested:	☑ Yes	☐ No	☐ N/A	6.
Containers Intact:	☑ Yes	☐ No	☐ N/A	7.
Sample Labels match COC: -Includes date/time/ID/Analysis	☑ Yes	☐ No	☐ N/A	8.
All containers needing acid/base pres. have been checked? **exceptions: VOA, coliform, TOC, O&G**	☑ Yes	☐ No	☐ N/A	9. (Circle) (HNO3) H2SO4 (NaOH) HCl
All containers needing preservation are found to be in compliance with EPA recommendation.	☑ Yes	☐ No	☐ N/A	
Headspace in VOA Vials (>6mm):	☐ Yes	☑ No	☐ N/A	10.
Trip Blank Present:	☐ Yes	☑ No	☐ N/A	11.
Trip Blank Custody Seals Present	☐ Yes	☐ No	☑ N/A	
Project Manager Review				
Samples Arrived within Hold Time:	☑ Yes	☐ No	☐ N/A	12.
Sufficient Volume:	☑ Yes	☐ No	☐ N/A	13.
Correct Containers Used:	☑ Yes	☐ No	☐ N/A	14.

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

Person Contacted: ________ Date/Time: ________

Comments/ Resolution: ________

Project Manager Review: Kenneth Hunt **Date:** 8/18/11

Form F-IN-Q290-rev.04, 28Apr2011

Sample Container Count

CLIENT: ARCOM

COC PAGE 1 of 1

COC ID# ______

Project # 5047787

Sample Line Item	DG9H	AG1U	WGFU	AG0U	R 4/6	BP2N	BP2U	BP2S	BP3N	BP3U	BP3S	AG3S	AG1H	BP3C		Comments
1	3			2					1					1		
2	3			2					1					1		
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

Container Codes

DG9H	40mL HCL amber voa vial	AG0U	100mL unpreserved amber glass	BP1N	1 liter HNO3 plastic	DG9P	40mL TSP amber vial
AG1U	1liter unpreserved amber glass	AG1H	1 liter HCL amber glass	BP1S	1 liter H2SO4 plastic	DG9S	40mL H2SO4 amber vial
WGFU	4oz clear soil jar	AG1S	1 liter H2SO4 amber glass	BP1U	1 liter unpreserved plastic	DG9T	40mL Na Thio amber vial
R	terra core kit	AG1T	1 liter Na Thiosulfate amber gl	BP1Z	1 liter NaOH, Zn, Ac	DG9U	40mL unpreserved **amber** vial
BP2N	500mL HNO3 plastic	AG2N	500mL HNO3 amber glass	BP2A	500mL NaOH, Asc Acid plastic	I	Wipe/Swab
BP2U	500mL unpreserved plastic	AG2S	500mL H2SO4 amber glass	BP2O	500mL NaOH plastic	JGFU	4oz unpreserved amber wide
BP2S	500mL H2SO4 plastic	AG2U	500mL unpreserved amber gla	BP2Z	500mL NaOH, Zn Ac	U	Summa Can
BP3N	250mL HNO3 plastic	AG3U	250mL unpreserved amber gla	AF	Air Filter	VG9H	40mL HCL clear vial
BP3U	250mL unpreserved plastic	BG1H	1 liter HCL clear glass	BP3C	250mL NaOH plastic	VG9T	40mL Na Thio. clear vial
BP3S	250mL H2SO4 plastic	BG1S	1 liter H2SO4 clear glass	BP3Z	250mL NaOH, Zn Ac plastic	VG9U	40mL unpreserved **clear** vial
AG3S	250mL H2SO4 glass amber	BG1T	1 liter Na Thiosulfate clear gla	C	Air Cassettes	VSG	Headspace septa vial & HCL
AG1S	1 liter H2SO4 amber glass	BG1U	1 liter unpreserved glass	DG9B	40mL Na Bisulfate amber vial	WGFX	4oz wide jar w/hexane wipe
BP1U	1 liter unpreserved plastic	BP1A	1 liter NaOH, Asc Acid plastic	DG9M	40mL MeOH clear vial	ZPLC	Ziploc Bag

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August 22, 2012

Nathan Conniff
AECOM
8902 Vincennes Circle
Indianapolis, IN 46268

RE: Project: Richmond MGP
Pace Project No.: 5067788

Dear Nathan Conniff:

Enclosed are the analytical results for sample(s) received by the laboratory on August 18, 2012. 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.

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

Sincerely,

Lyle Cable

lyle.cable@pacelabs.com
Project Manager

Enclosures

cc: Jeffrey Nelson

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CERTIFICATIONS

Project:	Richmond MGP
Pace Project No.:	5067788

Green Bay Certification IDs

1241 Bellevue Street, Green Bay, WI 54302
Florida/NELAP Certification #: E87948
Illinois Certification #: 200050
Kentucky Certification #: 82
Louisiana Certification #: 04168
Minnesota Certification #: 055-999-334
New York Certification #: 11888
North Carolina Certification #: 503
North Dakota Certification #: R-150
South Carolina Certification #: 83006001
US Dept of Agriculture #: S-76505
Wisconsin Certification #: 405132750

Indiana Certification IDs

7726 Moller Road, Indianapolis, IN 46268
Illinois Certification #: 200074
Indiana Certification #: C-49-06
Kansas Certification #: E-10247
Kentucky Certification #: 0042
Louisiana/NELAC Certification #: 04076
Ohio VAP Certification #: CL0065
Pennsylvania Certification #: 68-04991
West Virginia Certification #: 330

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SAMPLE SUMMARY

Project: Richmond MGP
Pace Project No.: 5067788

Lab ID	Sample ID	Matrix	Date Collected	Date Received
5067788001	**MW-015 (22-23)**	Solid	08/17/12 10:08	08/18/12 12:07
5067788002	**MW-015 (23-25)**	Solid	08/17/12 10:09	08/18/12 12:07

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SAMPLE ANALYTE COUNT

Project: Richmond MGP
Pace Project No.: 5067788

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
5067788001	**MW-015 (22-23)**	EPA 8270 by SIM	CEM	19	PASI-I
		EPA 8260	JLZ	7	PASI-I
		ASTM D2974-87	DAE	1	PASI-I
		Walkley Black	TJJ	1	PASI-G
5067788002	**MW-015 (23-25)**	EPA 8270 by SIM	CEM	19	PASI-I
		EPA 8260	JLZ	7	PASI-I
		ASTM D2974-87	DAE	1	PASI-I
		Walkley Black	TJJ	1	PASI-G

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ANALYTICAL RESULTS

Project: Richmond MGP
Pace Project No.: 5067788

Sample: MW-015 (22-23) **Lab ID: 5067788001** Collected: 08/17/12 10:08 Received: 08/18/12 12:07 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
8270 MSSV PAH by SIM	Analytical Method: EPA 8270 by SIM Preparation Method: EPA 3546							
Acenaphthene	**11700**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	83-32-9	
Acenaphthylene	**3120**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	208-96-8	
Anthracene	**6630**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	120-12-7	
Benzo(a)anthracene	**4070**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	56-55-3	
Benzo(a)pyrene	**2940**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	50-32-8	
Benzo(b)fluoranthene	**1270**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	205-99-2	
Benzo(g,h,i)perylene	**993**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	191-24-2	
Benzo(k)fluoranthene	**1430**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	207-08-9	
Chrysene	**4170**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	218-01-9	
Dibenz(a,h)anthracene	**495**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	53-70-3	
Fluoranthene	**7860**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	206-44-0	
Fluorene	**4310**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	86-73-7	
Indeno(1,2,3-cd)pyrene	**829**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	193-39-5	
2-Methylnaphthalene	**909**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	91-57-6	
Naphthalene	**1440**	ug/kg	5.6	1	08/20/12 11:45	08/20/12 19:35	91-20-3	
Phenanthrene	**10800**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	85-01-8	
Pyrene	**14600**	ug/kg	113	20	08/20/12 11:45	08/22/12 10:44	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	62	%.	46-109	1	08/20/12 11:45	08/20/12 19:35	321-60-8	
p-Terphenyl-d14 (S)	78	%.	43-107	1	08/20/12 11:45	08/20/12 19:35	1718-51-0	
8260 MSV UST Low Level	Analytical Method: EPA 8260							
Benzene	**186J**	ug/kg	282	50		08/20/12 17:48	71-43-2	D3,J
Ethylbenzene	**2360**	ug/kg	282	50		08/20/12 17:48	100-41-4	
Toluene	ND	ug/kg	282	50		08/20/12 17:48	108-88-3	
Xylene (Total)	**875**	ug/kg	564	50		08/20/12 17:48	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	92	%.	71-125	50		08/20/12 17:48	1868-53-7	
Toluene-d8 (S)	97	%.	76-124	50		08/20/12 17:48	2037-26-5	
4-Bromofluorobenzene (S)	114	%.	67-134	50		08/20/12 17:48	460-00-4	
Percent Moisture	Analytical Method: ASTM D2974-87							
Percent Moisture	**11.4**	%	0.10	1		08/20/12 17:02		
Organic Carbon Walkley Black	Analytical Method: Walkley Black							
Total Organic Carbon	**11200**	mg/kg	820	1	08/21/12 09:18	08/21/12 12:38	7440-44-0	

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ANALYTICAL RESULTS

Project: Richmond MGP
Pace Project No.: 5067788

Sample: MW-015 (23-25) **Lab ID: 5067788002** Collected: 08/17/12 10:09 Received: 08/18/12 12:07 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
8270 MSSV PAH by SIM	Analytical Method: EPA 8270 by SIM Preparation Method: EPA 3546							
Acenaphthene	**5760**	ug/kg	57.0	10	08/20/12 11:45	08/22/12 10:26	83-32-9	
Acenaphthylene	**744**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	208-96-8	
Anthracene	**2710**	ug/kg	57.0	10	08/20/12 11:45	08/22/12 10:26	120-12-7	
Benzo(a)anthracene	**1300**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	56-55-3	
Benzo(a)pyrene	**996**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	50-32-8	
Benzo(b)fluoranthene	**463**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	205-99-2	
Benzo(g,h,i)perylene	**453**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	191-24-2	
Benzo(k)fluoranthene	**535**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	207-08-9	
Chrysene	**1220**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	218-01-9	
Dibenz(a,h)anthracene	**193**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	53-70-3	
Fluoranthene	**3470**	ug/kg	57.0	10	08/20/12 11:45	08/22/12 10:26	206-44-0	
Fluorene	**2680**	ug/kg	57.0	10	08/20/12 11:45	08/22/12 10:26	86-73-7	
Indeno(1,2,3-cd)pyrene	**344**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	193-39-5	
2-Methylnaphthalene	**1140**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	91-57-6	
Naphthalene	**1600**	ug/kg	5.7	1	08/20/12 11:45	08/20/12 19:54	91-20-3	
Phenanthrene	**7260**	ug/kg	57.0	10	08/20/12 11:45	08/22/12 10:26	85-01-8	
Pyrene	**4730**	ug/kg	57.0	10	08/20/12 11:45	08/22/12 10:26	129-00-0	
Surrogates								
2-Fluorobiphenyl (S)	61	%.	46-109	1	08/20/12 11:45	08/20/12 19:54	321-60-8	
p-Terphenyl-d14 (S)	65	%.	43-107	1	08/20/12 11:45	08/20/12 19:54	1718-51-0	
8260 MSV UST Low Level	Analytical Method: EPA 8260							
Benzene	**79.5J**	ug/kg	285	50		08/20/12 18:23	71-43-2	D3,J
Ethylbenzene	**972**	ug/kg	285	50		08/20/12 18:23	100-41-4	
Toluene	ND	ug/kg	285	50		08/20/12 18:23	108-88-3	
Xylene (Total)	ND	ug/kg	570	50		08/20/12 18:23	1330-20-7	
Surrogates								
Dibromofluoromethane (S)	92	%.	71-125	50		08/20/12 18:23	1868-53-7	
Toluene-d8 (S)	96	%.	76-124	50		08/20/12 18:23	2037-26-5	
4-Bromofluorobenzene (S)	107	%.	67-134	50		08/20/12 18:23	460-00-4	
Percent Moisture	Analytical Method: ASTM D2974-87							
Percent Moisture	**12.2**	%	0.10	1		08/20/12 17:02		
Organic Carbon Walkley Black	Analytical Method: Walkley Black							
Total Organic Carbon	**15600**	mg/kg	1050	1	08/21/12 09:18	08/21/12 12:38	7440-44-0	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067788

QC Batch: MSV/45012
Analysis Method: EPA 8260
QC Batch Method: EPA 8260
Analysis Description: 8260 MSV UST Low Level
Associated Lab Samples: 5067788001, 5067788002

METHOD BLANK: 784375
Matrix: Solid
Associated Lab Samples: 5067788001, 5067788002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Benzene	ug/kg	ND	5.0	08/20/12 10:02	
Ethylbenzene	ug/kg	ND	5.0	08/20/12 10:02	
Toluene	ug/kg	ND	5.0	08/20/12 10:02	
Xylene (Total)	ug/kg	ND	10.0	08/20/12 10:02	
4-Bromofluorobenzene (S)	%.	91	67-134	08/20/12 10:02	
Dibromofluoromethane (S)	%.	94	71-125	08/20/12 10:02	
Toluene-d8 (S)	%.	97	76-124	08/20/12 10:02	

LABORATORY CONTROL SAMPLE: 784376

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Benzene	ug/kg	50	53.7	107	73-115	
Ethylbenzene	ug/kg	50	57.2	114	73-120	
Toluene	ug/kg	50	52.5	105	69-115	
Xylene (Total)	ug/kg	150	165	110	69-117	
4-Bromofluorobenzene (S)	%.			99	67-134	
Dibromofluoromethane (S)	%.			94	71-125	
Toluene-d8 (S)	%.			99	76-124	

MATRIX SPIKE SAMPLE: 784377

Parameter	Units	5067788002 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Benzene	ug/kg	79.5J	2850	3060	105	23-138	
Ethylbenzene	ug/kg	972	2850	3980	105	10-135	
Toluene	ug/kg	ND	2850	2770	96	10-131	
Xylene (Total)	ug/kg	ND	8540	9390	110	10-131	
4-Bromofluorobenzene (S)	%.				104	67-134	
Dibromofluoromethane (S)	%.				91	71-125	
Toluene-d8 (S)	%.				97	76-124	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067788

QC Batch: OEXT/30479 Analysis Method: EPA 8270 by SIM
QC Batch Method: EPA 3546 Analysis Description: 8270 MSSV PAH by SIM
Associated Lab Samples: 5067788001, 5067788002

METHOD BLANK: 784220 Matrix: Solid
Associated Lab Samples: 5067788001, 5067788002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
2-Methylnaphthalene	ug/kg	ND	5.0	08/20/12 17:10	
Acenaphthene	ug/kg	ND	5.0	08/20/12 17:10	
Acenaphthylene	ug/kg	ND	5.0	08/20/12 17:10	
Anthracene	ug/kg	ND	5.0	08/20/12 17:10	
Benzo(a)anthracene	ug/kg	ND	5.0	08/20/12 17:10	
Benzo(a)pyrene	ug/kg	ND	5.0	08/20/12 17:10	
Benzo(b)fluoranthene	ug/kg	ND	5.0	08/20/12 17:10	
Benzo(g,h,i)perylene	ug/kg	ND	5.0	08/20/12 17:10	
Benzo(k)fluoranthene	ug/kg	ND	5.0	08/20/12 17:10	
Chrysene	ug/kg	ND	5.0	08/20/12 17:10	
Dibenz(a,h)anthracene	ug/kg	ND	5.0	08/20/12 17:10	
Fluoranthene	ug/kg	ND	5.0	08/20/12 17:10	
Fluorene	ug/kg	ND	5.0	08/20/12 17:10	
Indeno(1,2,3-cd)pyrene	ug/kg	ND	5.0	08/20/12 17:10	
Naphthalene	ug/kg	ND	5.0	08/20/12 17:10	
Phenanthrene	ug/kg	ND	5.0	08/20/12 17:10	
Pyrene	ug/kg	ND	5.0	08/20/12 17:10	
2-Fluorobiphenyl (S)	%.	79	46-109	08/20/12 17:10	
p-Terphenyl-d14 (S)	%.	85	43-107	08/20/12 17:10	

LABORATORY CONTROL SAMPLE: 784221

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
2-Methylnaphthalene	ug/kg	333	224	67	49-116	
Acenaphthene	ug/kg	333	238	71	52-114	
Acenaphthylene	ug/kg	333	252	76	52-119	
Anthracene	ug/kg	333	263	79	55-124	
Benzo(a)anthracene	ug/kg	333	280	84	52-122	
Benzo(a)pyrene	ug/kg	333	284	85	56-131	
Benzo(b)fluoranthene	ug/kg	333	264	79	54-125	
Benzo(g,h,i)perylene	ug/kg	333	251	75	55-122	
Benzo(k)fluoranthene	ug/kg	333	248	74	55-128	
Chrysene	ug/kg	333	266	80	56-118	
Dibenz(a,h)anthracene	ug/kg	333	255	76	56-125	
Fluoranthene	ug/kg	333	272	82	55-125	
Fluorene	ug/kg	333	247	74	54-120	
Indeno(1,2,3-cd)pyrene	ug/kg	333	257	77	56-124	
Naphthalene	ug/kg	333	219	66	52-112	
Phenanthrene	ug/kg	333	250	75	53-116	
Pyrene	ug/kg	333	273	82	55-120	
2-Fluorobiphenyl (S)	%.			68	46-109	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067788

LABORATORY CONTROL SAMPLE: 784221

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
p-Terphenyl-d14 (S)	%.			82	43-107	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 784222 784223

Parameter	Units	5067737004 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
2-Methylnaphthalene	ug/kg	7.7	413	413	335	391	79	93	43-106	15	20	
Acenaphthene	ug/kg	ND	413	413	271	313	65	76	46-101	15	20	
Acenaphthylene	ug/kg	ND	413	413	295	328	71	79	47-105	11	20	
Anthracene	ug/kg	ND	413	413	270	314	65	76	39-112	15	20	
Benzo(a)anthracene	ug/kg	ND	413	413	251	309	61	75	36-105	21	20	R1
Benzo(a)pyrene	ug/kg	ND	413	413	243	289	59	70	34-113	17	20	
Benzo(b)fluoranthene	ug/kg	ND	413	413	234	266	57	64	33-111	13	20	
Benzo(g,h,i)perylene	ug/kg	ND	413	413	223	233	54	56	26-109	4	20	
Benzo(k)fluoranthene	ug/kg	ND	413	413	223	277	54	67	31-116	22	20	R1
Chrysene	ug/kg	ND	413	413	240	268	58	65	34-109	11	20	
Dibenz(a,h)anthracene	ug/kg	ND	413	413	230	241	56	58	32-111	5	20	
Fluoranthene	ug/kg	ND	413	413	274	311	66	75	33-117	13	20	
Fluorene	ug/kg	ND	413	413	276	317	67	77	44-107	14	20	
Indeno(1,2,3-cd)pyrene	ug/kg	ND	413	413	228	239	55	58	27-113	5	20	
Naphthalene	ug/kg	ND	413	413	267	304	64	73	45-106	13	20	
Phenanthrene	ug/kg	ND	413	413	265	306	63	73	42-103	14	20	
Pyrene	ug/kg	ND	413	413	261	304	63	74	36-111	16	20	
2-Fluorobiphenyl (S)	%.						68	72	46-109		20	
p-Terphenyl-d14 (S)	%.						68	74	43-107		20	

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067788

QC Batch: PMST/7376
Analysis Method: ASTM D2974-87
QC Batch Method: ASTM D2974-87
Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 5067788001, 5067788002

SAMPLE DUPLICATE: 784360

Parameter	Units	5067766001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	16.9	25.2	39	5	R1

SAMPLE DUPLICATE: 784361

Parameter	Units	5067614001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	12.5	13.2	6	5	R1

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QUALITY CONTROL DATA

Project: Richmond MGP
Pace Project No.: 5067788

QC Batch: WETA/13733 — Analysis Method: Walkley Black
QC Batch Method: Walkley Black — Analysis Description: Organic Carbon
Associated Lab Samples: 5067788001, 5067788002

METHOD BLANK: 658521 — Matrix: Solid
Associated Lab Samples: 5067788001, 5067788002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Organic Carbon	mg/kg	ND	400	08/21/12 12:37	

LABORATORY CONTROL SAMPLE: 658522

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/kg	16000	17000	106	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 658523 658524

Parameter	Units	5067438009 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Total Organic Carbon	mg/kg	6280	85100	85100	95600	96900	105	106	80-120	1	20	

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QUALIFIERS

Project: Richmond MGP
Pace Project No.: 5067788

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.

PRL - Pace Reporting 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.

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TNI - The NELAC Institute.

LABORATORIES

PASI-G	Pace Analytical Services - Green Bay
PASI-I	Pace Analytical Services - Indianapolis

BATCH QUALIFIERS

Batch: WETA/13736

[WB] Results reported on dry weight basis per cited method.

ANALYTE QUALIFIERS

D3	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.
J	Analyte detected below reporting limit, therefore result is an estimate.
R1	RPD value was outside control limits.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Richmond MGP
Pace Project No.: 5067788

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
5067788001	**MW-015 (22-23)**	EPA 3546	OEXT/30479	EPA 8270 by SIM	MSSV/10759
5067788002	**MW-015 (23-25)**	EPA 3546	OEXT/30479	EPA 8270 by SIM	MSSV/10759
5067788001	**MW-015 (22-23)**	EPA 8260	MSV/45012		
5067788002	**MW-015 (23-25)**	EPA 8260	MSV/45012		
5067788001	**MW-015 (22-23)**	ASTM D2974-87	PMST/7376		
5067788002	**MW-015 (23-25)**	ASTM D2974-87	PMST/7376		
5067788001	**MW-015 (22-23)**	Walkley Black	WETA/13733	Walkley Black	WETA/13736
5067788002	**MW-015 (23-25)**	Walkley Black	WETA/13733	Walkley Black	WETA/13736

Pace Analytical®
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: of

1603041

Section A Required Client Information:

Company:	AECOM
Address:	8902 Vincennes Cir, Suite D
Email To:	Nathan.conniff@aecom.com
Phone:	317-735-3021
Fax:	317-735-3040
Requested Due Date/TAT:	RUSH 2 DAY

Section B Required Project Information:

Report To:	Nathan Conniff
Copy To:	
Purchase Order No.:	
Project Name:	Richmond MGP
Project Number:	

Section C Invoice Information:

Attention:	
Company Name:	
Address:	
Pace Quote Reference:	
Pace Project Manager:	LYLE CABLE
Pace Profile #:	

REGULATORY AGENCY

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

Site Location STATE: IN

5066788

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

Requested Analysis Filtered (Y/N): BTEX N; PAH + 2MN N

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COMPOSITE START DATE	COMPOSITE START TIME	COMPOSITE END/GRAB DATE	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	BTEX	PAH + 2MN	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	MW-015 (22-23)	SL	G	8/17/12	1008	—	—		1	1									X	X		-001
2	MW-015 (23-25)	SL	G	8/17/12	1009	—	—		1	1									X	X		-002
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						
11																						
12																						

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
	[signature] AECOM	8/17/12	2100	[signature] Pace	8/18/12	1207	1.9	Y	Y	Y

SAMPLER NAME AND SAMPLER SIGNATURE

PRINT Name of SAMPLER: Nathan Conniff

SIGNATURE of SAMPLER: [signature]

DATE Signed (MM/DD/YY): 8/17/12

ORIGINAL
w/ FedEx

*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.

Sample Condition Upon Receipt

Pace Analytical

Client Name: AECom Project # 5067788

Courier: ☑ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other ________ ____________

Tracking #: 8010 5428 5150

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

Date/Time 5035A kits placed in freezer ____________

Packing Material: ☑ Bubble Wrap ☐ Bubble Bags ☐ None ☐ Other ____________

Thermometer Used 1 2 3 4 6 A B C D (E) Type of Ice: (Wet) Blue None ☐ Samples on ice, cooling process has begun

Cooler Temperature 1.8°C Ice Visible in Sample Containers: ☐ yes ☑ no

(Corrected, if applicable)

Temp should be above freezing to 6°C

Date and Initials of person examining contents: KO 8/4/12

				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.
Short Hold Time Analysis (<72hr):	☐Yes	☑No	☐N/A	5.
Rush Turn Around Time Requested:	☑Yes	☐No	☐N/A	6.
Containers Intact:	☑Yes	☐No	☐N/A	7.
Sample Labels match COC: -Includes date/time/ID/Analysis	☑Yes	☐No	☐N/A	8.
All containers needing acid/base pres. have been checked? exceptions: VOA, coliform, TOC, O&G	☐Yes	☑No	☐N/A	9. (Circle) HNO3 H2SO4 NaOH HCl
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes	☐No	☑N/A	
Headspace in VOA Vials (>6mm)	☐Yes	☐No	☑N/A	10.
Trip Blank Present:	☐Yes	☐No	☑N/A	11.
Trip Blank Custody Seals Present	☐Yes	☐No	☑N/A	
Project Manager Review				
Samples Arrived within Hold Time:	☑Yes	☐No	☐N/A	12.
Sufficient Volume:	☑Yes	☐No	☐N/A	13.
Correct Containers Used:	☑Yes	☐No	☐N/A	14.

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

Person Contacted: ____________ Date/Time: ____________

Comments/ Resolution: ____________

Project Manager Review: Kenneth Hunt **Date:** 8/8/12

Form F-IN-Q290-rev.04, 28Apr2011

Sample Container Count

CLIENT: AECom

COC PAGE 1 of 1

COC ID# ____

Project # 5067288

Sample Line Item	DG9H	AG1U	WGFU	AG0U	R 4/6	BP2N	BP2U	BP2S	BP3N	BP3U	BP3S	AG3S	AG1H			Comments
1			1													
2			1													
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

Container Codes

DG9H	40mL HCL amber voa vial	AG0U	100mL unpreserved amber glass	BP1N	1 liter HNO3 plastic	DG9P	40mL TSP amber vial
AG1U	1liter unpreserved amber glass	AG1H	1 liter HCL amber glass	BP1S	1 liter H2SO4 plastic	DG9S	40mL H2SO4 amber vial
WGFU	4oz clear soil jar	AG1S	1 liter H2SO4 amber glass	BP1U	1 liter unpreserved plastic	DG9T	40mL Na Thio amber vial
R	terra core kit	AG1T	1 liter Na Thiosulfate amber gl	BP1Z	1 liter NaOH, Zn, Ac	DG9U	40mL unpreserved **amber** vial
BP2N	500mL HNO3 plastic	AG2N	500mL HNO3 amber glass	BP2A	500mL NaOH, Asc Acid plastic	I	Wipe/Swab
BP2U	500mL unpreserved plastic	AG2S	500mL H2SO4 amber glass	BP2O	500mL NaOH plastic	JGFU	4oz unpreserved amber wide
BP2S	500mL H2SO4 plastic	AG2U	500mL unpreserved amber gla	BP2Z	500mL NaOH, Zn Ac	U	Summa Can
BP3N	250mL HNO3 plastic	AG3U	250mL unpreserved amber gla	AF	Air Filter	VG9H	40mL HCL clear vial
BP3U	250mL unpreserved plastic	BG1H	1 liter HCL clear glass	BP3C	250mL NaOH plastic	VG9T	40mL Na Thio. clear vial
BP3S	250mL H2SO4 plastic	BG1S	1 liter H2SO4 clear glass	BP3Z	250mL NaOH, Zn Ac plastic	VG9U	40mL unpreserved **clear** vial
AG3S	250mL H2SO4 glass amber	BG1T	1 liter Na Thiosulfate clear gla	C	Air Cassettes	VSG	Headspace septa vial & HCL
AG1S	1 liter H2SO4 amber glass	BG1U	1 liter unpreserved glass	DG9B	40mL Na Bisulfate amber vial	WGFX	4oz wide jar w/hexane wipe
BP1U	1 liter unpreserved plastic	BP1A	1 liter NaOH, Asc Acid plastic	DG9M	40mL MeOH clear vial	ZPLC	Ziploc Bag

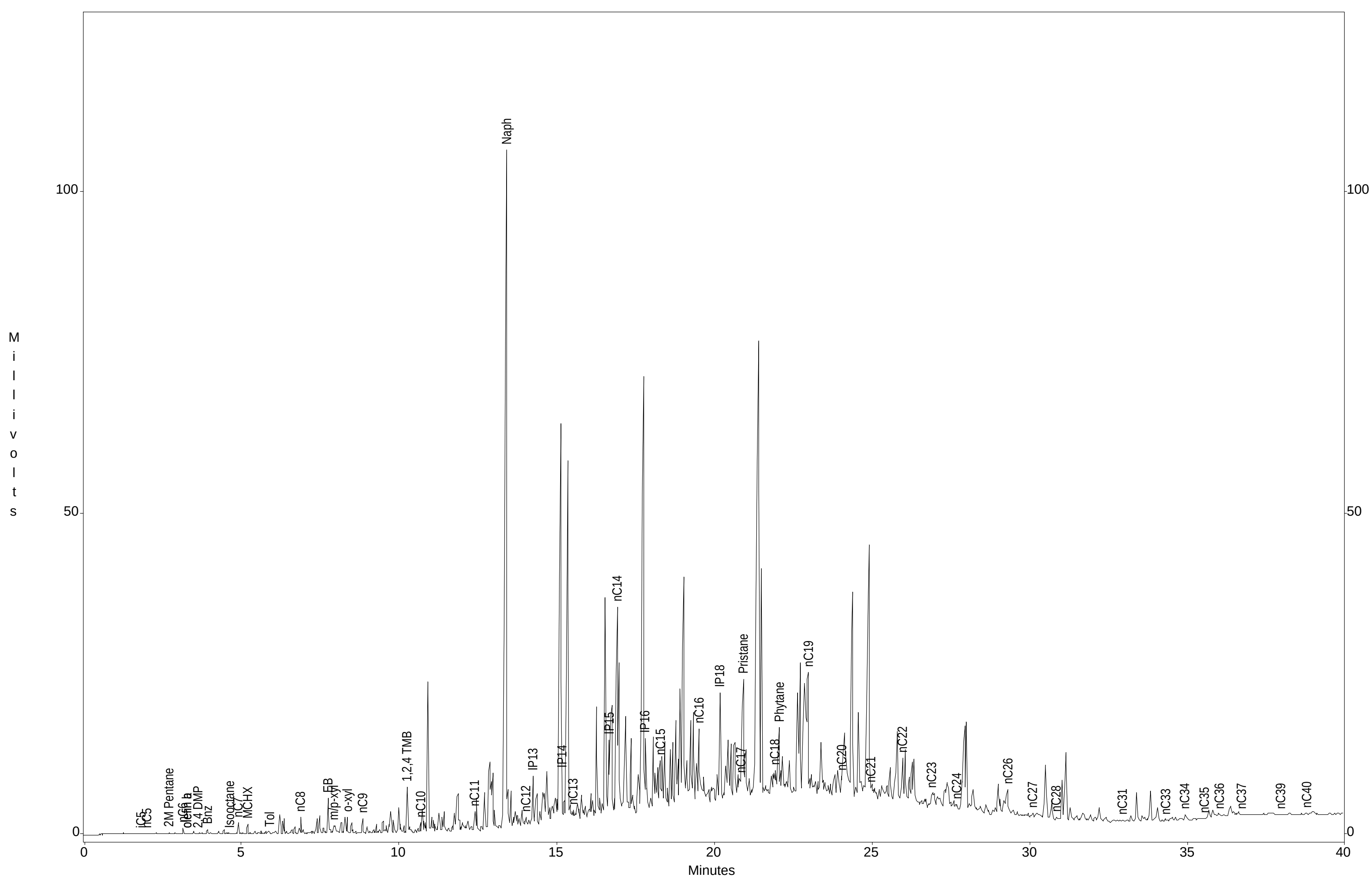
Torkelson Geochemistry, Inc.							
Physical Properties Measurements							
Sample	TGI Job Number	Density of NAPL (gm/ml)	Viscosity of NAPL (centipoise)	Surface Tension Air/Water (dynes/cm)	Interfacial Tension NAPL/Water (dynes/cm)	Surface Tension Air/NAPL (dynes/cm)	Temperature of Measurements
MW-001	12143	0.9914	28.5	NA	NA	NA	60F

NA = Not Analyzed

Torkelson Geochemistry, Inc.

Richmond, IN MGP, Richmond, IN
Sample ID : MW-001
Acquired : Aug 03, 2012 12:37:32

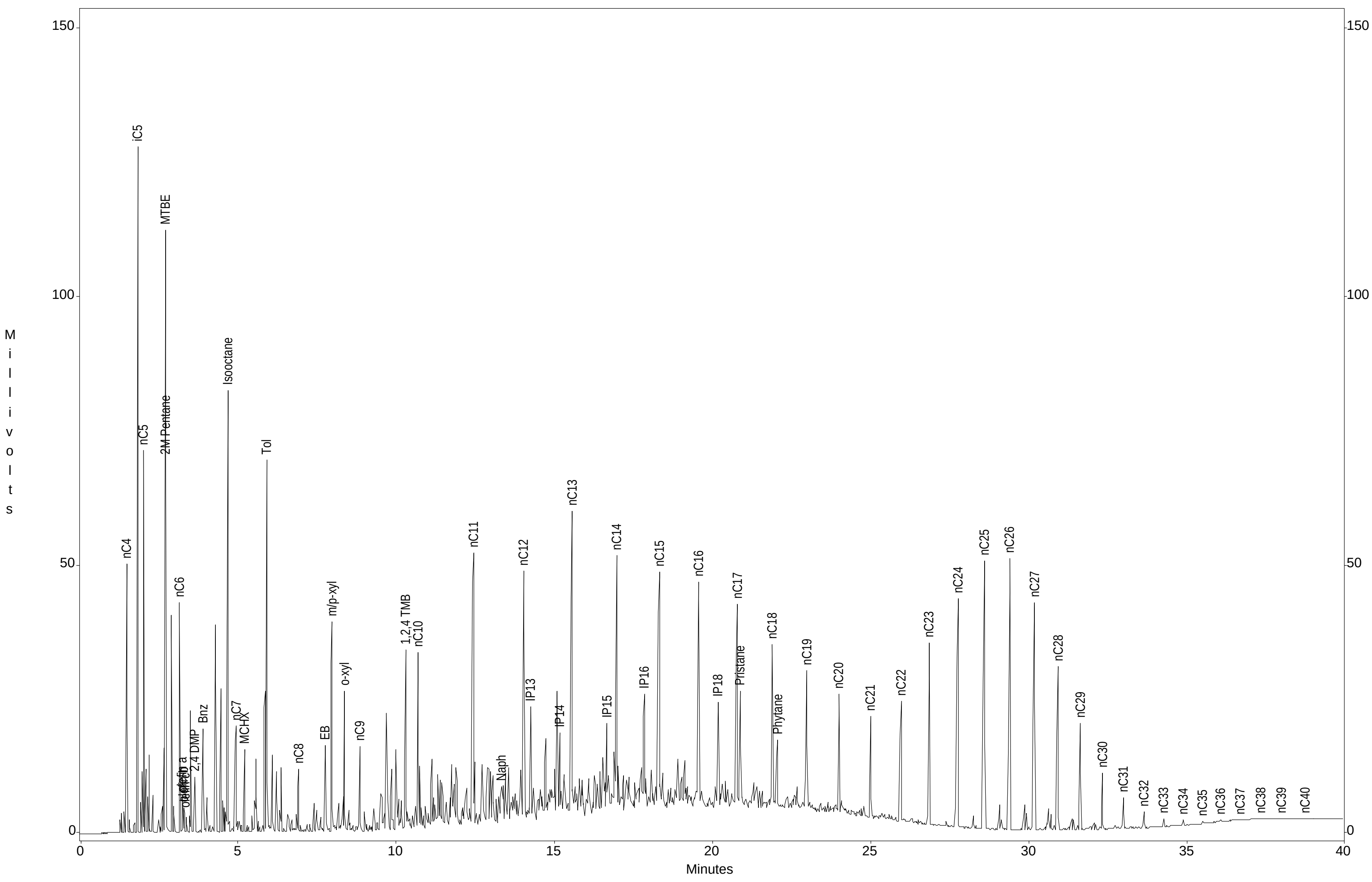
c:\ezchrom\chrom\12143\mw-001 -- Channel A



Torkelson Geochemistry, Inc.

Richmond, IN MGP, Richmond, IN
Sample ID : Gas/Dies/Wax std
Acquired : Aug 03, 2012 10:34:06

c:\ezchrom\chrom\12143\gadiwax2 -- Channel A



Torkelson Geochemistry, Inc.

Richmond, IN MGP, Richmond, IN
Sample ID : MW-001
Acquired : Aug 03, 2012 12:37:32

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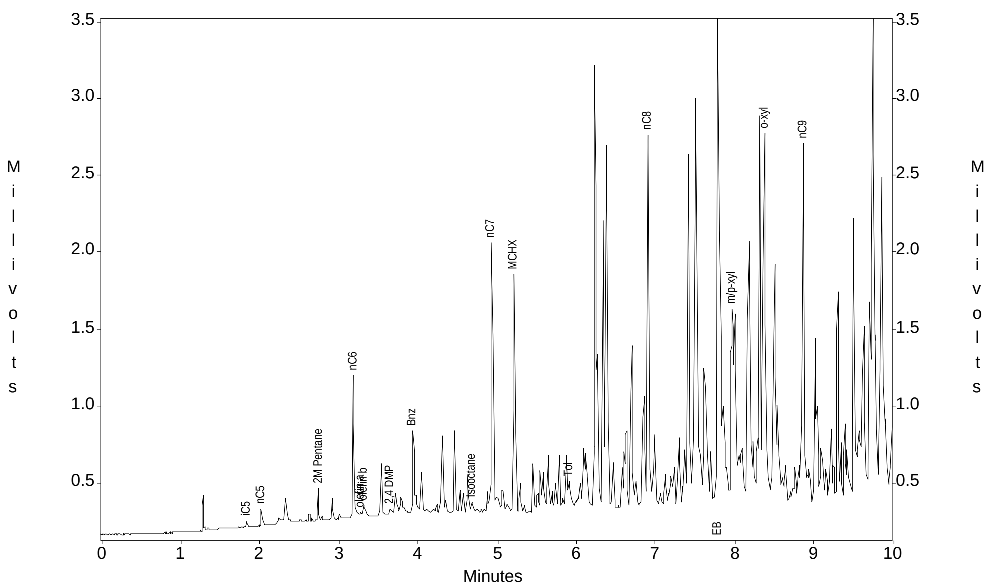

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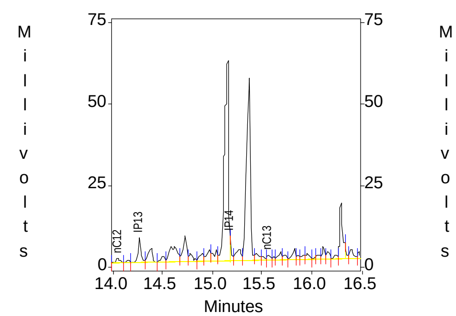

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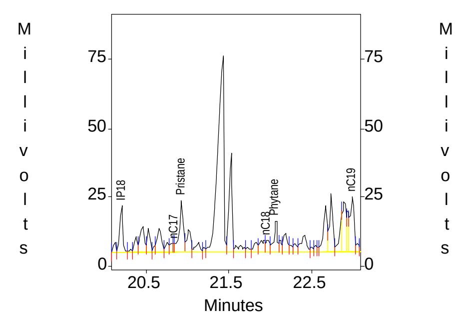
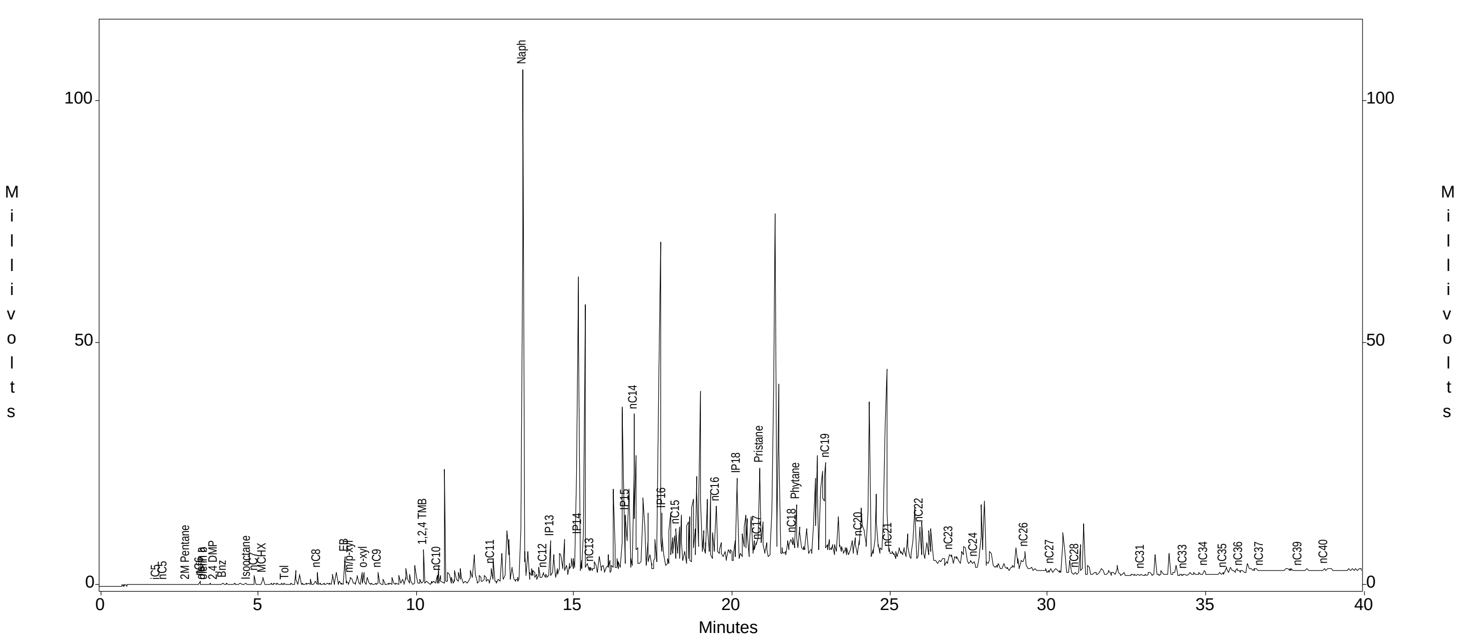


c:\ezchrom\chrom\12143\mw-001 -- Channel A

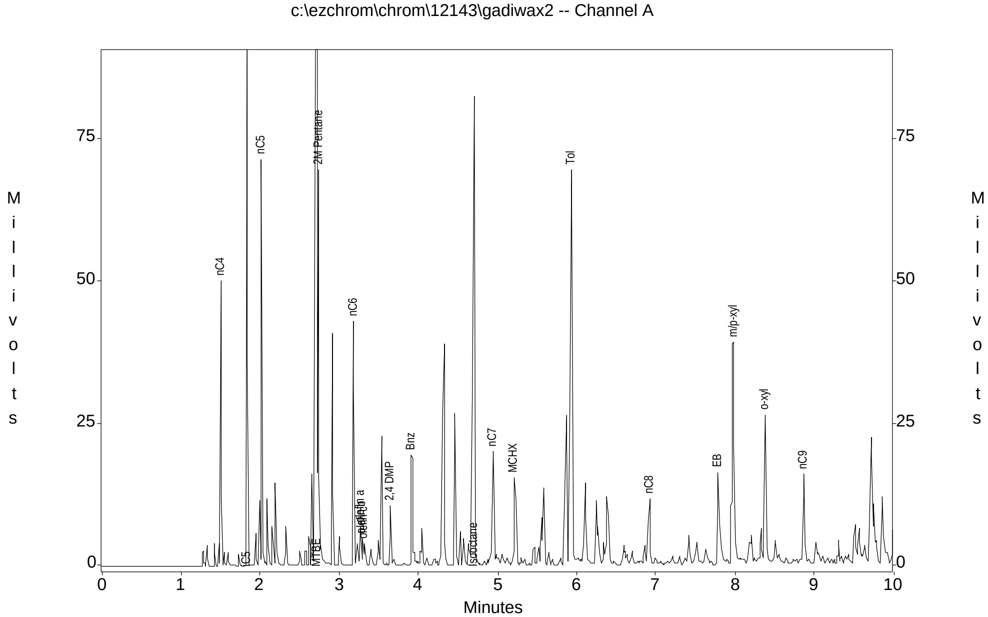


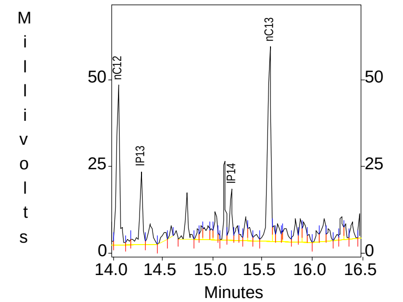
Channel A Results

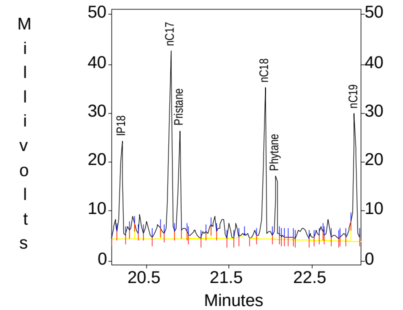
Peak	Area	Height
nC4	0	0
iC5	28	33
nC5	101	108
MTBE	0	0
2M Pentane	205	209
nC6	1093	924
olefin a	30	23
olefin b	133	69
olefin c	0	0
2,4 DMP	104	42
Bnz	947	528
Isooctane	98	60
nC7	2207	1747
MCHX	1936	1550
Tol	452	191
nC8	3319	2427
EB	8667	5624
m/p-xyl	1819	1283
o-xyl	4744	2414
nC9	3972	2334
1,2,4 TMB	12178	7218
nC10	2464	1469
nC11	5737	2885
Naph	397089	105547
nC12	4562	1357
IP13	15649	7566
IP14	6114	7579
nC13	3839	1579
IP15	21330	11902
nC14	85655	32393
IP16	22359	11241
nC15	21673	7462
nC16	23708	9987
IP18	42036	16875
nC17	5542	3323
Pristane	61565	18952
nC18	11596	4390
Phytane	34182	11215
nC19	60315	19595
nC20	8695	3285
nC21	2196	533
nC22	22907	7156
nC23	1992	910
nC24	2483	767
nC25	0	0
nC26	20285	4083
nC27	3284	751
nC28	908	292
nC29	0	0
nC30	0	0
nC31	698	277
nC32	0	0
nC33	1249	255
nC34	3306	752
nC35	106	50
nC36	326	148
nC37	92	57
nC38	0	0
nC39	39	19
nC40	727	174

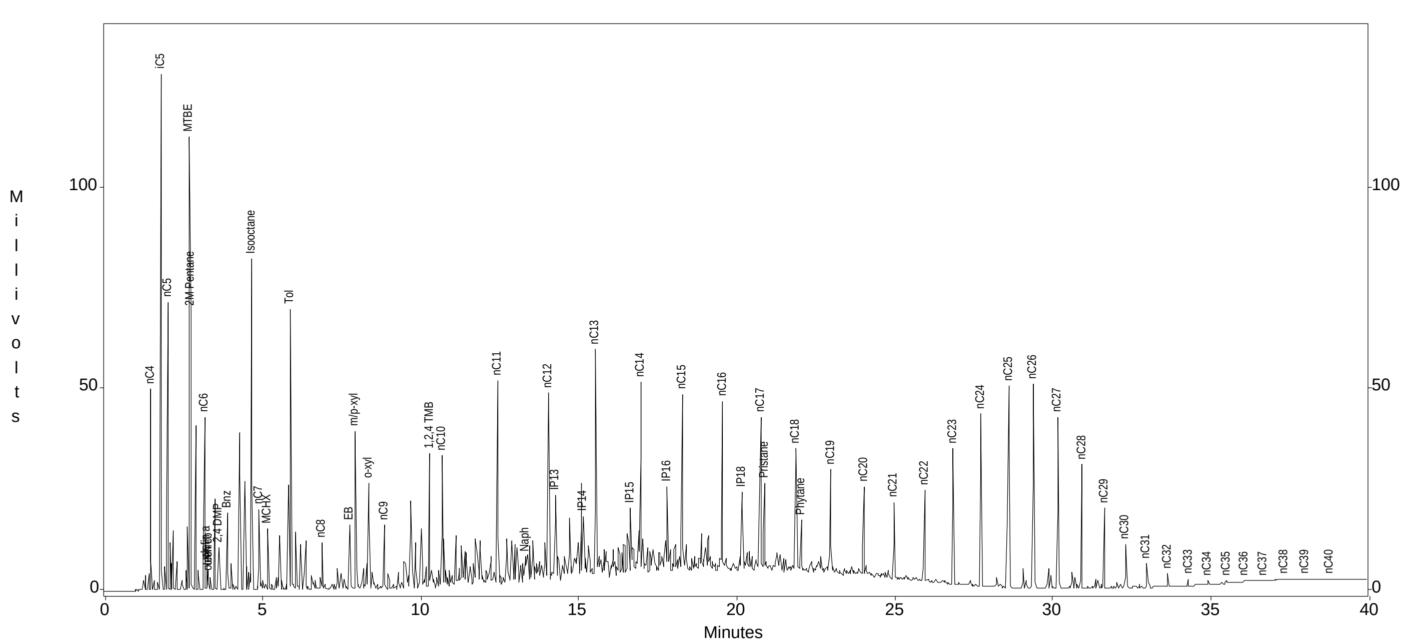
Torkelson Geochemistry, Inc.

Richmond, IN MGP, Richmond, IN
Sample ID : Gas/Dies/Wax std
Acquired : Aug 03, 2012 10:34:06









Channel A Results

Peak	Area	Height
nC4	30987	50106
iC5	87127	128016
nC5	52107	71442
MTBE	97923	112488
2M Pentane	61939	69500
nC6	42009	42986
olefin a	7114	6582
olefin b	4897	4655
olefin c	4834	3648
2,4 DMP	10668	10362
Bnz	25313	19253
Isooctane	122064	82387
nC7	25506	19911
MCHX	18960	15310
Tol	104741	69424
nC8	14757	11667
EB	24345	15955
m/p-xyl	93110	39107
o-xyl	41417	26188
nC9	23426	15816
1,2,4 TMB	62079	33303
nC10	52629	32699
nC11	96992	50596
Naph	23814	6609
nC12	99441	46639
IP13	44053	21071
IP14	24183	14703
nC13	117113	56423
IP15	23190	15321
nC14	96322	45912
IP16	48066	21454
nC15	98291	44293
nC16	91028	42205
IP18	43165	19813
nC17	85961	38194
Pristane	49016	21912
nC18	70656	30527
Phytane	27819	12783
nC19	55407	26004
nC20	39543	21738
nC21	37840	18985
nC22	45329	22603
nC23	75244	33864
nC24	117357	42631
nC25	142712	50007
nC26	148888	50657
nC27	115797	42341
nC28	73877	30642
nC29	41485	19902
nC30	19710	10474
nC31	10230	5634
nC32	5480	2977
nC33	2883	1618
nC34	1648	873
nC35	914	481
nC36	704	264
nC37	548	122
nC38	412	79
nC39	202	50
nC40	111	38

TGI

Torkelson Geochemistry, Inc.
2528 S. Columbia Place
Tulsa, OK 74114-3233
Phone: 918-749-8441
Fax: 918-749-6005
e-mail: BTorkelson@torkelsongeochemistry.com

CHAIN-OF-CUSTODY RECORD

Project: Richmond, IN MGP
Location: Richmond, IN
Proj. No.: 60194081
P.O.:
Sampled By: Nathan Conniff

Report/Bill To: Nathan Conniff
Address: AECOM
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268
Phone: 317-735-3021
Fax: 317-735-3040
e-mail: nathan.conniff@aecom.com

Additional Instructions

Requested Turn-Around Time: Standard

ITEM NO.	SAMPLE DESCRIPTION	DATE	MATRIX	LAB NO.	Total # OF Vials	PRESERVATIVES: None					ANALYSES REQUESTED: GC Characterization	Density	Viscosity	Water Surface Tension	NAPL Surface Tension	NAPL/Water Interfac. Tens.	Lead	Sulfur						REMARKS
1	MW-001	7/31/12	OL		3	3					X	X	X											include interpretation
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								

RELINQUISHED BY	DATE	TIME	ACCEPTED BY	DATE	TIME
[signature] AECOM	7/31/12	1900	[signature]	8-1-12	0900

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

ANALYTICAL REPORT

Job Number: 200-12185-1

Job Description: Richmond Former MGP Site

For:
AECOM, Inc.
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268

Attention: Mr. Nathan Conniff

Approved for release.
Sara S Goff
Project Manager I
9/27/2012 2:11 PM

Designee for
Don C Dawicki
Customer Service Manager
don.dawicki@testamericainc.com
09/27/2012

The test results in this report relate only to sample(s) as received by the laboratory. These test results were derived under a quality system that adheres to the requirements of NELAC. Pursuant to NELAC, this report may not be produced in full without written approval from the laboratory

TestAmerica Laboratories, Inc.
TestAmerica Burlington 30 Community Drive, Suite 11, South Burlington, VT 05403
Tel (802) 660-1990 Fax (802) 660-1919 www.testamericainc.com

CASE NARRATIVE

Client: AECOM, Inc.

Project: Richmond Former MGP Site

Report Number: 200-12185-1

With the exceptions noted as flags or footnotes, standard analytical protocols were followed in the analysis of the samples and no problems were encountered or anomalies observed. In addition all laboratory quality control samples were within established control limits, with any exceptions noted below. Each sample was analyzed to achieve the lowest possible reporting limit within the constraints of the method. In some cases, due to interference or analytes present at high concentrations, samples were diluted. For diluted samples, the reporting limits are adjusted relative to the dilution required.

Calculations are performed before rounding to avoid round-off errors in calculated results.

All holding times were met and proper preservation noted for the methods performed on these samples, unless otherwise detailed in the individual sections below.

After receipt in Burlington, sample volume analyzed for ASTM method D5084 was delivered toGeoTesting Express in Acton, MA. Those results are filed at the end of this case submittal in a section titled Subcontract Data.

RECEIPT
The samples were received on 08/01/2012; the samples arrived in good condition.

GRAIN SIZE
Sample SB-12-02 (24-28) was analyzed for grain size in accordance with D422 grain size. The samples were analyzed on 08/14/2012.

No difficulties were encountered during the grain size analysis.

All quality control parameters were within the acceptance limits.

DENSITY OF SOIL IN PLACE BY THE DRIVE CYLINDER METHOD
Sample SB-12-02 (24-28) was analyzed for Density of Soil in Place by the Drive Cylinder Method in accordance with D_2937. The samples were analyzed on 08/14/2012.

No difficulties were encountered during the density analysis.

All quality control parameters were within the acceptance limits.

SPECIFIC GRAVITY
Sample SB-12-02 (24-28) was analyzed for specific gravity in accordance with D854. The samples were analyzed on 08/14/2012.

No difficulties were encountered during the specific gravity analysis.

All quality control parameters were within the acceptance limits.

POROSITY
Sample SB-12-02 (24-28) was analyzed for porosity in accordance with Porosity. The samples were analyzed on 08/14/2012.

No difficulties were encountered during the porosity analysis.

All quality control parameters were within the acceptance limits.

EXECUTIVE SUMMARY - Detections

Client: AECOM, Inc. Job Number: 200-12185-1

Lab Sample ID Client Sample ID Analyte	Result	Qualifier	Reporting Limit	Units	Method
200-12185-1 SB-12-02 (24-28)					
In Place Density	1.90			g/cc	D2937
Sieve Size 3 inch - Percent Finer	100.0			% Passing	D422
Gravel	20.9			%	D422
Hydrometer Reading 1 - Particle Size	31.9			um	D422
Sieve Size 2 inch - Percent Finer	100.0			% Passing	D422
Sand	35.1			%	D422
Hydrometer Reading 2 - Particle Size	20.3			um	D422
Sieve Size 1.5 inch - Percent Finer	100.0			% Passing	D422
Coarse Sand	13.0			%	D422
Hydrometer Reading 3 - Particle Size	11.9			um	D422
Sieve Size 1 inch - Percent Finer	100.0			% Passing	D422
Medium Sand	11.6			%	D422
Hydrometer Reading 4 - Particle Size	8.4			um	D422
Sieve Size 0.75 inch - Percent Finer	100.0			% Passing	D422
Fine Sand	10.5			%	D422
Hydrometer Reading 5 - Particle Size	6.2			um	D422
Sieve Size 0.375 inch - Percent Finer	90.2			% Passing	D422
Silt	17.2			%	D422
Hydrometer Reading 6 - Particle Size	3.1			um	D422
Sieve Size #4 - Percent Finer	79.1			% Passing	D422
Clay	26.8			%	D422
Hydrometer Reading 7 - Particle Size	1.3			um	D422
Sieve Size #10 - Percent Finer	66.1			% Passing	D422
Sieve Size #20 - Percent Finer	59.0			% Passing	D422
Sieve Size #40 - Percent Finer	54.5			% Passing	D422
Sieve Size #60 - Percent Finer	50.5			% Passing	D422
Sieve Size #80 - Percent Finer	48.6			% Passing	D422
Sieve Size #100 - Percent Finer	47.5			% Passing	D422
Sieve Size #200 - Percent Finer	44.0			% Passing	D422
Hydrometer Reading 1 - Percent Finer	38.5			% Passing	D422
Hydrometer Reading 2 - Percent Finer	37.1			% Passing	D422
Hydrometer Reading 3 - Percent Finer	32.7			% Passing	D422
Hydrometer Reading 4 - Percent Finer	29.8			% Passing	D422
Hydrometer Reading 5 - Percent Finer	26.8			% Passing	D422
Hydrometer Reading 6 - Percent Finer	21.0			% Passing	D422
Hydrometer Reading 7 - Percent Finer	15.1			% Passing	D422
Specific Gravity at 20 deg Celsius	2.76			NONE	D854
Porosity	31.3			%	LAB-BUR
Void Ratio	0.5			NONE	LAB-BUR

METHOD SUMMARY

Client: AECOM, Inc. Job Number: 200-12185-1

Description	Lab Location	Method	Preparation Method
Matrix: Solid			
Density of Soil in Place by the Drive-Cylinder Method	TAL BUR	ASTM D2937	
Grain Size	TAL BUR	ASTM D422	
Specific Gravity of Soils	TAL BUR	ASTM D854	
Porosity	TAL BUR	ASTM LAB-BUR	
General Sub Contract Method	GeoTesting	Subcontract	

Lab References:

GeoTesting = GeoTesting - Boxboro

TAL BUR = TestAmerica Burlington

Method References:

ASTM = ASTM International

METHOD / ANALYST SUMMARY

Client: AECOM, Inc. Job Number: 200-12185-1

Method	Analyst	Analyst ID
ASTM D2937	Bourdeau, Timothy P	TPB
ASTM D422	Bourdeau, Timothy P	TPB
ASTM D854	Bourdeau, Timothy P	TPB
ASTM LAB-BUR	Bourdeau, Timothy P	TPB

SAMPLE SUMMARY

Client: AECOM, Inc.

Job Number: 200-12185-1

Lab Sample ID	Client Sample ID	Client Matrix	Date/Time Sampled	Date/Time Received
200-12185-1	SB-12-02 (24-28)	Solid	07/31/2012 1427	08/01/2012 1030

SAMPLE RESULTS

Analytical Data

Client: AECOM, Inc.　　　　Job Number: 200-12185-1

Client Sample ID: **SB-12-02 (24-28)**

Lab Sample ID: 200-12185-1　　　　Date Sampled: 07/31/2012 1427
Client Matrix: Solid　　　　Date Received: 08/01/2012 1030

D2937 Density of Soil in Place by the Drive-Cylinder Method

Analysis Method:	D2937	Analysis Batch:	200-43433	Instrument ID:	NOEQUIP
	N/A	Prep Batch:	N/A	Lab File ID:	N/A
Dilution:	1.0			Initial Weight/Volume:	
Analysis Date:	08/14/2012 1758			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (g/cc)	Qualifier	NONE	NONE
In Place Density		1.90			

Analytical Data

Client: AECOM, Inc. Job Number: 200-12185-1

Client Sample ID: **SB-12-02 (24-28)**

Lab Sample ID:	200-12185-1	Date Sampled:	07/31/2012 1427
Client Matrix:	Solid	Date Received:	08/01/2012 1030

D422 Grain Size

Analysis Method:	D422	Analysis Batch:	200-43620	Instrument ID:	D422_import
	N/A	Prep Batch:	N/A	Lab File ID:	200-12185-A-1.txt
Dilution:	1.0			Initial Weight/Volume:	59.76 g
Analysis Date:	08/14/2012 2303			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (% Passing)	Qualifier	NONE	NONE
Sieve Size 3 inch - Percent Finer		100.0			
Sieve Size 2 inch - Percent Finer		100.0			
Sieve Size 1.5 inch - Percent Finer		100.0			
Sieve Size 1 inch - Percent Finer		100.0			
Sieve Size 0.75 inch - Percent Finer		100.0			
Sieve Size 0.375 inch - Percent Finer		90.2			
Sieve Size #4 - Percent Finer		79.1			
Sieve Size #10 - Percent Finer		66.1			
Sieve Size #20 - Percent Finer		59.0			
Sieve Size #40 - Percent Finer		54.5			
Sieve Size #60 - Percent Finer		50.5			
Sieve Size #80 - Percent Finer		48.6			
Sieve Size #100 - Percent Finer		47.5			
Sieve Size #200 - Percent Finer		44.0			
Hydrometer Reading 1 - Percent Finer		38.5			
Hydrometer Reading 2 - Percent Finer		37.1			
Hydrometer Reading 3 - Percent Finer		32.7			
Hydrometer Reading 4 - Percent Finer		29.8			
Hydrometer Reading 5 - Percent Finer		26.8			
Hydrometer Reading 6 - Percent Finer		21.0			
Hydrometer Reading 7 - Percent Finer		15.1			

Client: AECOM, Inc. Job Number: 200-12185-1

Client Sample ID: SB-12-02 (24-28)

Lab Sample ID:	200-12185-1	Date Sampled:	07/31/2012 1427
Client Matrix:	Solid	Date Received:	08/01/2012 1030

D422 Grain Size

Analysis Method:	D422	Analysis Batch:	200-43620	Instrument ID:	D422_import
	N/A	Prep Batch:	N/A	Lab File ID:	200-12185-A-1.txt
Dilution:	1.0			Initial Weight/Volume:	59.76 g
Analysis Date:	08/14/2012 2303			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (%)	Qualifier	NONE	NONE
Gravel		20.9			
Sand		35.1			
Coarse Sand		13.0			
Medium Sand		11.6			
Fine Sand		10.5			
Silt		17.2			
Clay		26.8			

Client: AECOM, Inc.   Job Number: 200-12185-1

Client Sample ID: **SB-12-02 (24-28)**

Lab Sample ID:	200-12185-1	Date Sampled:	07/31/2012 1427
Client Matrix:	Solid	Date Received:	08/01/2012 1030

D422 Grain Size

Analysis Method:	D422	Analysis Batch:	200-43620	Instrument ID:	D422_import
	N/A	Prep Batch:	N/A	Lab File ID:	200-12185-A-1.txt
Dilution:	1.0			Initial Weight/Volume:	59.76 g
Analysis Date:	08/14/2012 2303			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (um)	Qualifier	NONE	NONE
Hydrometer Reading 1 - Particle Size		31.9			
Hydrometer Reading 2 - Particle Size		20.3			
Hydrometer Reading 3 - Particle Size		11.9			
Hydrometer Reading 4 - Particle Size		8.4			
Hydrometer Reading 5 - Particle Size		6.2			
Hydrometer Reading 6 - Particle Size		3.1			
Hydrometer Reading 7 - Particle Size		1.3			

Client: AECOM, Inc.

Job Number: 200-12185-1

Client Sample ID: **SB-12-02 (24-28)**

Lab Sample ID: 200-12185-1
Client Matrix: Solid

Date Sampled: 07/31/2012 1427
Date Received: 08/01/2012 1030

D854 Specific Gravity of Soils

Analysis Method:	D854	Analysis Batch:	200-43432	Instrument ID:	NOEQUIP
	N/A	Prep Batch:	N/A	Lab File ID:	N/A
Dilution:	1.0			Initial Weight/Volume:	
Analysis Date:	08/14/2012 2305			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (NONE)	Qualifier	NONE	NONE
Specific Gravity at 20 deg Celsius		2.76			

Analytical Data

Client: AECOM, Inc. Job Number: 200-12185-1

Client Sample ID: **SB-12-02 (24-28)**

Lab Sample ID:	200-12185-1	Date Sampled: 07/31/2012 1427
Client Matrix:	Solid	Date Received: 08/01/2012 1030

LAB-BUR Porosity

Analysis Method:	LAB-BUR	Analysis Batch:	200-43434	Instrument ID:	NOEQUIP
	N/A	Prep Batch:	N/A	Lab File ID:	N/A
Dilution:	1.0			Initial Weight/Volume:	
Analysis Date:	08/14/2012 2313			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (%)	Qualifier	NONE	NONE
Porosity		31.3			

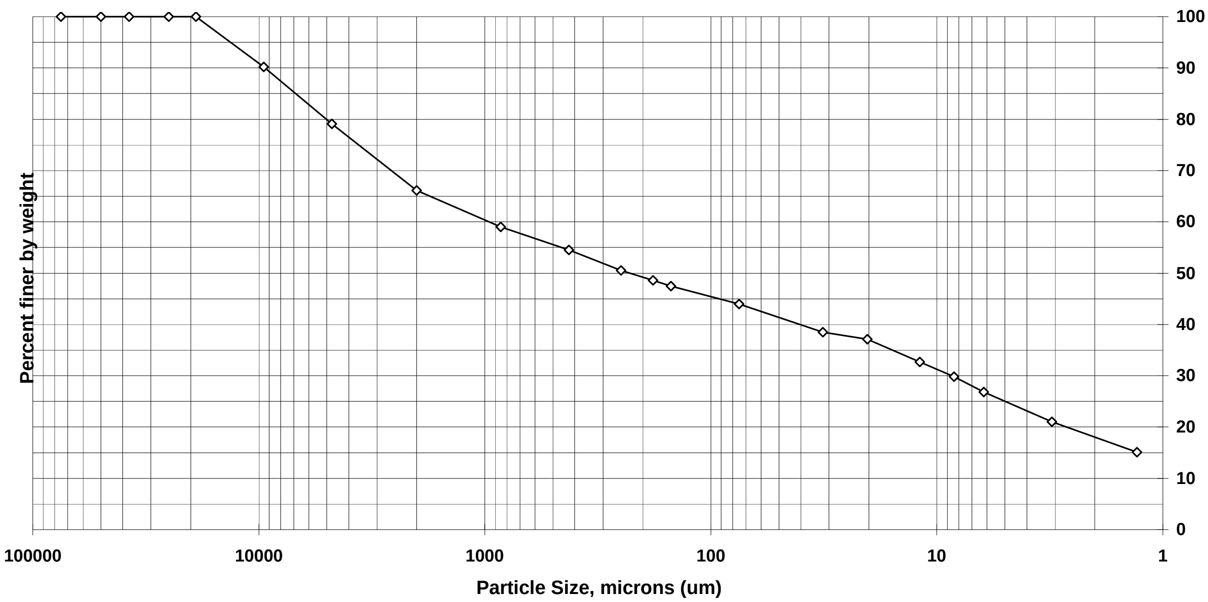
Analyte	DryWt Corrected: N	Result (NONE)	Qualifier	NONE	NONE
Void Ratio		0.5			

Particle Size of Soils by ASTM D422

				Date Received:	8/1/2012
Sample ID:	SB-12-02 (24-28)	**Percent Solids:**	89.7%	**Start Date:**	8/14/2012
Lab ID:	200-12185-A-1	**Specific Gravity:**	2.758	**End Date:**	8/18/2012

Shape (> #10): angular

Non-soil material: na
Hardness (> #10): hard



Sieve size	Particle size, um	Percent finer	Incremental percent
3 inch	75000	100.0	0.0
2 inch	50000	100.0	0.0
1.5 inch	37500	100.0	0.0
1 inch	25000	100.0	0.0
3/4 inch	19000	100.0	0.0
3/8 inch	9500	90.2	9.8
#4	4750	79.1	11.1
#10	2000	66.1	13.0
#20	850	59.0	7.1
#40	425	54.5	4.5
#60	250	50.5	4.0
#80	180	48.6	1.9
#100	150	47.5	1.1
#200	75	44.0	3.5
Hyd1	31.9	38.5	5.5
Hyd2	20.3	37.1	1.4
Hyd3	11.9	32.7	4.4
Hyd4	8.4	29.8	2.9
Hyd5	6.2	26.8	3.0
Hyd6	3.1	21.0	5.8
Hyd7	1.3	15.1	5.9

Soil Classification	Percent of sample
Gravel	20.9
Sand	35.1
Coarse Sand	13.0
Medium Sand	11.6
Fine Sand	10.5
Silt	17.2
Clay	26.8

TestAmerica Burlington

Sediment Grain Size - D422

Client	
Client Sample ID	SB-12-02 (24-28)
Lab Sample ID	200-12185-A-1

Date Received	8/1/2012
Start Date	08/14/2012 23:03
End Date	08/18/2012 5:01

Dry Weight Determination

Tin Weight	4.07	g
Wet Sample + Tin	593.50	g
Dry Sample + Tin	532.87	g
% Moisture	10.29	%

Non-soil material:	na
Shape (> #10):	angular
Hardness (> #10):	hard

Date/Time in oven	08/14/2012 23:10
Date/Time out of oven	08/15/2012 19:23

Sample Weights	Tare (g)	Pan+Samp (g)	Samp (g)
Sample Weight (Wet)		59.76	59.76
Sample Weight (Oven Dried)			53.6

Sample Split (oven dried)	Tare (g)	Pan+Samp (g)	Samp (g)
Sample >=#10			18.2
Sample <#10			35.4
% Passing #10			59.2

Hydrometer Data

Serial Number	540534
Calib. Date (mm/dd/yyyy)	05/06/2010
Low Temp (C)	17.0
Reading at Low Temp	1.0040
High Temp (C)	23.0
Reading at High Temp	1.0030
Hydrometer Cal Slope	-0.000166667
Hydrometer Cal Intercept	1.006833333
Default Soil Gravity	2.7576

Gravel/Sand Fraction (Sieves)

Sample Fraction	Size (um)	Pan Tare (g)	Pan+Sample (g)	Sample		% Finer	Classification	Sub Class
3 inch	75000			0.00	g	100.0	Gravel	
2 inch	50000			0.00	g	100.0	Gravel	
1.5 inch	37500			0.00	g	100.0	Gravel	
1 inch	25000			0.00	g	100.0	Gravel	
3/4 inch	19000			0.00	g	100.0	Gravel	
3/8 inch	9500	447.46	452.72	5.26	g	90.2	Gravel	
#4	4750	488.23	494.16	5.93	g	79.1	Gravel	
#10	2000	462.88	469.87	6.99	g	66.1	Sand	Coarse
#20	850	383.11	386.90	3.79	g	59.0	Sand	Medium
#40	425	353.36	355.79	2.43	g	54.5	Sand	Medium
#60	250	341.31	343.43	2.12	g	50.5	Sand	Fine
#80	180	330.61	331.63	1.02	g	48.6	Sand	Fine
#100	150	327.78	328.37	0.59	g	47.5	Sand	Fine
#200	75	312.09	313.94	1.85	g	44.0	Sand	Fine
				0.00	g	44.0		

Adjusted Hydrometer Sample Mass

Hydrometer Sample Mass (g)	53.6

Silt/Clay Fraction (Hydrometer Test)

Hydrometer Test Time (min)	Actual	Spec. Gravity	Temp C	Particle Size (Micron)	% Finer	Classification	Sub Class
2	2	1.0165	21.0	31.9	38.5	Silt	
5	5	1.0160	21.0	20.3	37.1	Silt	
15	15	1.0145	21.0	11.9	32.7	Silt	
30	31	1.0135	21.0	8.4	29.8	Silt	
60	57	1.0125	21.0	6.2	26.8	Silt	
250	235	1.0105	21.0	3.1	21	Clay	
1440	1382	1.0085	21.0	1.3	15.1	Clay	

DATA REPORTING QUALIFIERS

Lab Section	Qualifier	Description

QUALITY CONTROL RESULTS

Client: AECOM, Inc. Job Number: 200-12185-1

QC Association Summary

Lab Sample ID	Client Sample ID	Report Basis	Client Matrix	Method	Prep Batch
Geotechnical					
Analysis Batch:200-43432					
200-12185-1	SB-12-02 (24-28)	T	Solid	D854	
Analysis Batch:200-43433					
200-12185-1	SB-12-02 (24-28)	T	Solid	D2937	
Analysis Batch:200-43434					
200-12185-1	SB-12-02 (24-28)	T	Solid	LAB-BUR	
Analysis Batch:200-43620					
200-12185-1	SB-12-02 (24-28)	T	Solid	D422	

Report Basis
T = Total

Client:	Test America		
Project Name:	Richmond Former MGP Site		
Project Location:	---		
GTX #:	12153		
Start Date:	9/5/2012	Tested By:	ema
End Date:	9/7/2012	Checked By:	jdt
Boring #:	---		
Sample #:	SB-12-02 (24-28)		
Depth:	---		
Visual Description:	Moist, brown sandy silt with gravel		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D 5084

Constant Volume

Sample Type: Remolded
Permeant Fluid: De-aired Distilled water
Orientation: Vertical
Cell #: 2/2/4

Sample Preparation: Test specimen remolded using moderate effort at the as-received moisture content. Material >3/8-inch removed from sample prior to testing (~25% of sample). Trimmings moisture content = 14.1%

Parameter	Initial	Final
Height, in	2.02	1.99
Diameter, in	2.85	2.80
Area, in^2	6.38	6.16
Volume, in^3	12.9	12.3
Mass, g	356	390
Bulk Density, pcf	105	121
Moisture Content, %	14.8	25.5
Dry Density, pcf	91.6	96.3
Degree of Saturation, %	---	95

B COEFFICIENT DETERMINATION

Cell Pressure, psi: 95.1
Pressure Increment, psi: 5.03
Sample Pressure, psi: 90.3
B Coefficient: 0.98

FLOW DATA

Date	Trial #	Pressure, psi		Manometer Readings			Elapsed Time, sec	Gradient	Permeability K, cm/sec	Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
		Cell	Sample	Z_1	Z_2	Z_1-Z_2						
9/6	3	90	85	7.0	6.0	1.0	23	17.4	2.1E-06	20	1.000	2.1E-06
9/6	4	90	85	7.0	6.0	1.0	23	17.4	2.1E-06	20	1.000	2.1E-06
9/6	5	90	85	7.0	6.0	1.0	24	17.4	2.0E-06	20	1.000	2.0E-06
9/6	6	90	85	7.0	6.0	1.0	24	17.4	2.0E-06	20	1.000	2.0E-06

PERMEABILITY AT 20° C: 2.1×10^{-6} cm/sec (@ 5 psi effective stress)

Chain of Custody Record

TAL-4124 (1007)

Temperature on Receipt ______

Drinking Water? Yes ☐ No ☒

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Client	AECOM
Address	8902 Vincennes Circle, Ste. D
City	Indianapolis
State	IN
Zip Code	46268
Project Name and Location (State)	Richmond former MGP Site
Contract/Purchase Order/Quote No.	
Project Manager	Jeffrey Nelson
Telephone Number (Area Code)/Fax Number	812-334-8315
Site Contact	Nathan Conniff
Lab Contact	
Carrier/Waybill Number	FedEx 8744 32475536
Date	7/31/12
Lab Number	
Chain of Custody Number	201419
Page	1 of 1

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix: Air	Aqueous	Sed.	Soil		Containers & Preservatives: Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc/NaOH		Analysis: Porosity	Permeability	Grain Size	Special Instructions/ Conditions of Receipt
SB-12-02 (24-28)	7/31/12	1427				X		X							X	X	X	

Possible Hazard Identification: ☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For ____ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☒ Other Standard

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished By: [signature]	7/31/12	1900	1. Received By: [signature] TA-BUR	8/1/12	1030
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: WHITE - Returned to Client with Report; CANARY - Stays with the Sample; PINK - Field Copy

FedEx Express US Airbill

FedEx Tracking Number 8744 3247 5536

Form ID No. 0215

1 From

Date

FedEx Tracking Number 874432475536

Sender's Name

Phone

Company

Address

Dept/Floor/Suite/Room

City State ZIP

2 Your Internal Billing Reference

3 To

Recipient's Name

Phone

Company

Address

We cannot deliver to P.O. boxes or P.O. ZIP codes.

HOLD Weekday
FedEx location address REQUIRED. NOT available for FedEx First Overnight.

Address

Use this line for the HOLD location address or for continuation of your shipping address.

HOLD Saturday
FedEx location address REQUIRED. Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.

City State ZIP

4a Express Package Service * To most locations. Packages up to 150 lbs.

- [ ] FedEx Priority Overnight — Next business morning.* Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx Standard Overnight — Next business afternoon.* Saturday Delivery NOT available.
- [ ] FedEx First Overnight — Earliest next business morning delivery to select locations.*
- [ ] FedEx 2Day — Second business day.* Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx Express Saver — Third business day.* Saturday Delivery NOT available.

4b Express Freight Service ** To most locations. Packages over 150 lbs.

- [ ] FedEx 1Day Freight — Next business day.** Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.

FedEx 1Day Freight Booking No.

- [ ] FedEx 2Day Freight — Second business day.** Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx 3Day Freight — Third business day.** Saturday Delivery NOT available.

5 Packaging * Declared value limit $500.

- [ ] FedEx Envelope*
- [ ] FedEx Pak* — Includes FedEx Small Pak and FedEx Large Pak.
- [ ] FedEx Box
- [ ] FedEx Tube
- [ ] Othe

6 Special Handling and Delivery Signature Options

- [ ] SATURDAY Delivery — NOT available for FedEx Standard Overnight, FedEx Express Saver, or FedEx 3Day Freight.
- [ ] No Signature Required — Package may be left without obtaining a signature for delivery.
- [ ] Direct Signature — Someone at recipient's address may sign for delivery. Fee applies.
- [ ] Indirect Signature — If no one is available at recipient's address, someone at a neighboring address may sign for delivery. For residential deliveries only. Fee applies.

Does this shipment contain dangerous goods?

- [x] No
- [ ] Yes — As per attached Shipper's Declaration.
- [ ] Yes — Shipper's Declaration not required.
- [ ] Dry Ice — Dry Ice, 9, UN 1845 ____ x ____ kg

Dangerous goods (including dry ice) cannot be shipped in FedEx packaging or placed in a FedEx Express Drop Box.

- [ ] Cargo Aircraft Only

7 Payment *Bill to:*

Enter FedEx Acct. No. or Credit Card No. below.

- [ ] Sender — Acct. No. in Section 1 will be billed.
- [ ] Recipient
- [ ] Third Party
- [ ] Credit Card
- [ ] Cash/Chec

Total Packages Total Weight ____ lbs. Credit Card Auth.

†Our liability is limited to $100 unless you declare a higher value. See the current FedEx Service Guide for details.

605

fedex.com 1.800.GoFedEx 1.800.463.3339

Login Sample Receipt Checklist

Client: AECOM, Inc.

Job Number: 200-12185-1

Login Number: 12185

List Source: TestAmerica Burlington

List Number: 1

Creator: Kirchner, Benjamin

Question	Answer	Comment
Radioactivity either was not measured or, if measured, is at or below background	N/A	Lab does not accept radioactive samples.
The cooler's custody seal, if present, is intact.	True	977571
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	N/A	Thermal preservation not required.
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	18.4ºC, IR GUN 154, CF -0.2
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the sample IDs on the containers and the COC.	True	
Samples are received within Holding Time.	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
VOA sample vials do not have headspace or bubble is <6mm (1/4") in diameter.	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

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ANALYTICAL REPORT

Job Number: 200-12410-1

Job Description: Richmond Former MGP Site

For:
AECOM, Inc.
8902 Vincennes Circle, Suite D
Indianapolis, IN 46268

Attention: Mr. Nathan Conniff

Approved for release.
Sara S Goff
Project Manager I
9/27/2012 2:10 PM

Designee for
Don C Dawicki
Customer Service Manager
don.dawicki@testamericainc.com
09/27/2012

The test results in this report relate only to sample(s) as received by the laboratory. These test results were derived under a quality system that adheres to the requirements of NELAC. Pursuant to NELAC, this report may not be produced in full without written approval from the laboratory

TestAmerica Laboratories, Inc.
TestAmerica Burlington 30 Community Drive, Suite 11, South Burlington, VT 05403
Tel (802) 660-1990 Fax (802) 660-1919 www.testamericainc.com

CASE NARRATIVE

Client: AECOM, Inc.

Project: Richmond Former MGP Site

Report Number: 200-12410-1

With the exceptions noted as flags or footnotes, standard analytical protocols were followed in the analysis of the samples and no problems were encountered or anomalies observed. In addition all laboratory quality control samples were within established control limits, with any exceptions noted below. Each sample was analyzed to achieve the lowest possible reporting limit within the constraints of the method. In some cases, due to interference or analytes present at high concentrations, samples were diluted. For diluted samples, the reporting limits are adjusted relative to the dilution required.

Calculations are performed before rounding to avoid round-off errors in calculated results.

All holding times were met and proper preservation noted for the methods performed on these samples, unless otherwise detailed in the individual sections below.

After receipt in Burlington, sample volume analyzed for ASTM method D5084 was delivered toGeoTesting Express in Acton, MA. Those results are filed at the end of this case submittal in a section titled Subcontract Data.

RECEIPT
The samples were received on 08/21/2012; the samples arrived in good condition.

No sample information recorded on the sample container. Sample logged in per the chain of custody.

GRAIN SIZE
Sample MW-012D (14-16) was analyzed for grain size in accordance with D422 grain size. The samples were analyzed on 08/28/2012.

No difficulties were encountered during the grain size analysis.

All quality control parameters were within the acceptance limits.

DENSITY OF SOIL IN PLACE BY THE DRIVE CYLINDER METHOD
Sample MW-012D (14-16) was analyzed for Density of Soil in Place by the Drive Cylinder Method in accordance with D_2937. The samples were analyzed on 08/28/2012.

No difficulties were encountered during the density analysis.

All quality control parameters were within the acceptance limits.

SPECIFIC GRAVITY
Sample MW-012D (14-16) was analyzed for specific gravity in accordance with D854. The samples were analyzed on 08/28/2012.

No difficulties were encountered during the specific gravity analysis.

All quality control parameters were within the acceptance limits.

POROSITY
Sample MW-012D (14-16) was analyzed for porosity in accordance with Porosity. The samples were analyzed on 08/28/2012.

No difficulties were encountered during the porosity analysis.

All quality control parameters were within the acceptance limits.

EXECUTIVE SUMMARY - Detections

Client: AECOM, Inc. Job Number: 200-12410-1

Lab Sample ID Client Sample ID Analyte	Result	Qualifier	Reporting Limit	Units	Method
200-12410-1 MW-012D (14-16)					
In Place Density	1.83			g/cc	D2937
Sieve Size 3 inch - Percent Finer	100.0			% Passing	D422
Gravel	4.3			%	D422
Hydrometer Reading 1 - Particle Size	32.6			um	D422
Sieve Size 2 inch - Percent Finer	100.0			% Passing	D422
Sand	54.7			%	D422
Hydrometer Reading 2 - Particle Size	21.0			um	D422
Sieve Size 1.5 inch - Percent Finer	100.0			% Passing	D422
Coarse Sand	5.6			%	D422
Hydrometer Reading 3 - Particle Size	12.4			um	D422
Sieve Size 1 inch - Percent Finer	100.0			% Passing	D422
Medium Sand	17.5			%	D422
Hydrometer Reading 4 - Particle Size	8.9			um	D422
Sieve Size 0.75 inch - Percent Finer	100.0			% Passing	D422
Fine Sand	31.6			%	D422
Hydrometer Reading 5 - Particle Size	6.5			um	D422
Sieve Size 0.375 inch - Percent Finer	100.0			% Passing	D422
Silt	21.1			%	D422
Hydrometer Reading 6 - Particle Size	3.1			um	D422
Sieve Size #4 - Percent Finer	95.7			% Passing	D422
Clay	19.9			%	D422
Hydrometer Reading 7 - Particle Size	1.3			um	D422
Sieve Size #10 - Percent Finer	90.1			% Passing	D422
Sieve Size #20 - Percent Finer	82.0			% Passing	D422
Sieve Size #40 - Percent Finer	72.6			% Passing	D422
Sieve Size #60 - Percent Finer	61.4			% Passing	D422
Sieve Size #80 - Percent Finer	54.9			% Passing	D422
Sieve Size #100 - Percent Finer	50.6			% Passing	D422
Sieve Size #200 - Percent Finer	41.0			% Passing	D422
Hydrometer Reading 1 - Percent Finer	33.9			% Passing	D422
Hydrometer Reading 2 - Percent Finer	30.4			% Passing	D422
Hydrometer Reading 3 - Percent Finer	24.6			% Passing	D422
Hydrometer Reading 4 - Percent Finer	22.3			% Passing	D422
Hydrometer Reading 5 - Percent Finer	19.9			% Passing	D422
Hydrometer Reading 6 - Percent Finer	17.6			% Passing	D422
Hydrometer Reading 7 - Percent Finer	14.3			% Passing	D422
Specific Gravity at 20 deg Celsius	2.69			NONE	D854
Porosity	32.2			%	LAB-BUR
Void Ratio	0.5			NONE	LAB-BUR

METHOD SUMMARY

Client: AECOM, Inc. Job Number: 200-12410-1

Description	Lab Location	Method	Preparation Method
Matrix: Solid			
Density of Soil in Place by the Drive-Cylinder Method	TAL BUR	ASTM D2937	
Grain Size	TAL BUR	ASTM D422	
Specific Gravity of Soils	TAL BUR	ASTM D854	
Porosity	TAL BUR	ASTM LAB-BUR	
General Sub Contract Method	GeoTesting	Subcontract	

Lab References:

GeoTesting = GeoTesting - Boxboro

TAL BUR = TestAmerica Burlington

Method References:

ASTM = ASTM International

METHOD / ANALYST SUMMARY

Client: AECOM, Inc. Job Number: 200-12410-1

Method	Analyst	Analyst ID
ASTM D2937	Peterson, Mark A	MAP
ASTM D422	Peterson, Mark A	MAP
ASTM D854	Peterson, Mark A	MAP
ASTM LAB-BUR	Peterson, Mark A	MAP

SAMPLE SUMMARY

Client: AECOM, Inc.

Job Number: 200-12410-1

Lab Sample ID	Client Sample ID	Client Matrix	Date/Time Sampled	Date/Time Received
200-12410-1	MW-012D (14-16)	Solid	08/16/2012 1802	08/21/2012 1005

SAMPLE RESULTS

Client: AECOM, Inc. Job Number: 200-12410-1

Client Sample ID: **MW-012D (14-16)**

Lab Sample ID: 200-12410-1 Date Sampled: 08/16/2012 1802
Client Matrix: Solid Date Received: 08/21/2012 1005

D2937 Density of Soil in Place by the Drive-Cylinder Method

Analysis Method:	D2937	Analysis Batch:	200-44122	Instrument ID:	NOEQUIP
	N/A	Prep Batch:	N/A	Lab File ID:	N/A
Dilution:	1.0			Initial Weight/Volume:	
Analysis Date:	08/28/2012 2117			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (g/cc)	Qualifier	NONE	NONE
In Place Density		1.83			

Client: AECOM, Inc. Job Number: 200-12410-1

Client Sample ID:	**MW-012D (14-16)**		
Lab Sample ID:	200-12410-1	Date Sampled:	08/16/2012 1802
Client Matrix:	Solid	Date Received:	08/21/2012 1005

D422 Grain Size

Analysis Method:	D422	Analysis Batch:	200-44297	Instrument ID:	D422_import
	N/A	Prep Batch:	N/A	Lab File ID:	200-12410-A-1.txt
Dilution:	1.0			Initial Weight/Volume:	81.51 g
Analysis Date:	08/28/2012 2147			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (% Passing)	Qualifier	NONE	NONE
Sieve Size 3 inch - Percent Finer		100.0			
Sieve Size 2 inch - Percent Finer		100.0			
Sieve Size 1.5 inch - Percent Finer		100.0			
Sieve Size 1 inch - Percent Finer		100.0			
Sieve Size 0.75 inch - Percent Finer		100.0			
Sieve Size 0.375 inch - Percent Finer		100.0			
Sieve Size #4 - Percent Finer		95.7			
Sieve Size #10 - Percent Finer		90.1			
Sieve Size #20 - Percent Finer		82.0			
Sieve Size #40 - Percent Finer		72.6			
Sieve Size #60 - Percent Finer		61.4			
Sieve Size #80 - Percent Finer		54.9			
Sieve Size #100 - Percent Finer		50.6			
Sieve Size #200 - Percent Finer		41.0			
Hydrometer Reading 1 - Percent Finer		33.9			
Hydrometer Reading 2 - Percent Finer		30.4			
Hydrometer Reading 3 - Percent Finer		24.6			
Hydrometer Reading 4 - Percent Finer		22.3			
Hydrometer Reading 5 - Percent Finer		19.9			
Hydrometer Reading 6 - Percent Finer		17.6			
Hydrometer Reading 7 - Percent Finer		14.3			

Client: AECOM, Inc. Job Number: 200-12410-1

Client Sample ID: **MW-012D (14-16)**

Lab Sample ID: 200-12410-1 Date Sampled: 08/16/2012 1802
Client Matrix: Solid Date Received: 08/21/2012 1005

D422 Grain Size

Analysis Method:	D422	Analysis Batch:	200-44297	Instrument ID:	D422_import
	N/A	Prep Batch:	N/A	Lab File ID:	200-12410-A-1.txt
Dilution:	1.0			Initial Weight/Volume:	81.51 g
Analysis Date:	08/28/2012 2147			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (%)	Qualifier	NONE	NONE
Gravel		4.3			
Sand		54.7			
Coarse Sand		5.6			
Medium Sand		17.5			
Fine Sand		31.6			
Silt		21.1			
Clay		19.9			

Client: AECOM, Inc. Job Number: 200-12410-1

Client Sample ID: **MW-012D (14-16)**

Lab Sample ID: 200-12410-1 Date Sampled: 08/16/2012 1802
Client Matrix: Solid Date Received: 08/21/2012 1005

D422 Grain Size

Analysis Method:	D422	Analysis Batch:	200-44297	Instrument ID:	D422_import
	N/A	Prep Batch:	N/A	Lab File ID:	200-12410-A-1.txt
Dilution:	1.0			Initial Weight/Volume:	81.51 g
Analysis Date:	08/28/2012 2147			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (um)	Qualifier	NONE	NONE
Hydrometer Reading 1 - Particle Size		32.6			
Hydrometer Reading 2 - Particle Size		21.0			
Hydrometer Reading 3 - Particle Size		12.4			
Hydrometer Reading 4 - Particle Size		8.9			
Hydrometer Reading 5 - Particle Size		6.5			
Hydrometer Reading 6 - Particle Size		3.1			
Hydrometer Reading 7 - Particle Size		1.3			

Client: AECOM, Inc. | Job Number: 200-12410-1

Client Sample ID: **MW-012D (14-16)**

Lab Sample ID:	200-12410-1	Date Sampled: 08/16/2012 1802
Client Matrix:	Solid	Date Received: 08/21/2012 1005

D854 Specific Gravity of Soils

Analysis Method:	D854	Analysis Batch:	200-44121	Instrument ID:	NOEQUIP
	N/A	Prep Batch:	N/A	Lab File ID:	N/A
Dilution:	1.0			Initial Weight/Volume:	
Analysis Date:	08/28/2012 2118			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (NONE)	Qualifier	NONE	NONE
Specific Gravity at 20 deg Celsius		2.69			

Client: AECOM, Inc. Job Number: 200-12410-1

Client Sample ID: **MW-012D (14-16)**

Lab Sample ID:	200-12410-1	Date Sampled:	08/16/2012 1802
Client Matrix:	Solid	Date Received:	08/21/2012 1005

LAB-BUR Porosity

Analysis Method:	LAB-BUR	Analysis Batch:	200-44120	Instrument ID:	NOEQUIP
	N/A	Prep Batch:	N/A	Lab File ID:	N/A
Dilution:	1.0			Initial Weight/Volume:	
Analysis Date:	08/28/2012 2119			Final Weight/Volume:	
Prep Date:	N/A				

Analyte	DryWt Corrected: N	Result (%)	Qualifier	NONE	NONE
Porosity		32.2			

Analyte	DryWt Corrected: N	Result (NONE)	Qualifier	NONE	NONE
Void Ratio		0.5			

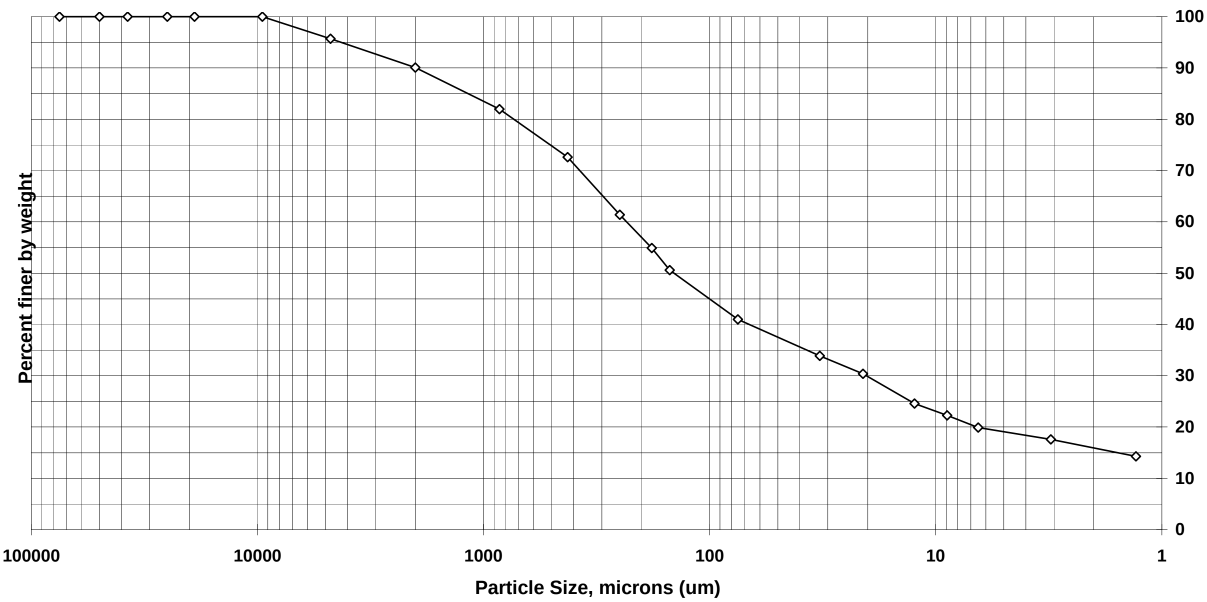
Particle Size of Soils by ASTM D422

Sample ID:	MW-012D (14-16)	**Percent Solids:**	84.7%	**Date Received:**	8/21/2012
Lab ID:	200-12410-A-1	**Specific Gravity:**	2.650	**Start Date:**	8/28/2012
				End Date:	8/31/2012

Shape (> #10): subrounded

Non-soil material: na

Hardness (> #10): hard



Sieve size	Particle size, um	Percent finer	Incremental percent
3 inch	75000	100.0	0.0
2 inch	50000	100.0	0.0
1.5 inch	37500	100.0	0.0
1 inch	25000	100.0	0.0
3/4 inch	19000	100.0	0.0
3/8 inch	9500	100.0	0.0
#4	4750	95.7	4.3
#10	2000	90.1	5.6
#20	850	82.0	8.1
#40	425	72.6	9.4
#60	250	61.4	11.2
#80	180	54.9	6.5
#100	150	50.6	4.3
#200	75	41.0	9.6
Hyd1	32.6	33.9	7.1
Hyd2	21	30.4	3.5
Hyd3	12.4	24.6	5.8
Hyd4	8.9	22.3	2.3
Hyd5	6.5	19.9	2.4
Hyd6	3.1	17.6	2.3
Hyd7	1.3	14.3	3.3

Soil Classification	Percent of sample
Gravel	4.3
Sand	54.7
Coarse Sand	5.6
Medium Sand	17.5
Fine Sand	31.6
Silt	21.1
Clay	19.9

TestAmerica Burlington

Sediment Grain Size - D422

Client		Date Received	8/21/2012
Client Sample ID	MW-012D (14-16)	Start Date	08/28/2012 21:47
Lab Sample ID	200-12410-A-1	End Date	08/31/2012 6:23

Dry Weight Determination

Tin Weight	25.17	g
Wet Sample + Tin	1047.91	g
Dry Sample + Tin	891.67	g
% Moisture	15.28	%

Non-soil material:	na
Shape (> #10):	subrounded
Hardness (> #10):	hard

Date/Time in oven	08/28/2012 21:48
Date/Time out of oven	08/29/2012 19:15

Sample Weights	Tare (g)	Pan+Samp (g)	Samp (g)
Sample Weight (Wet)		81.51	81.51
Sample Weight (Oven Dried)			69.1

Sample Split (oven dried)	Tare (g)	Pan+Samp (g)	Samp (g)
Sample >=#10			6.8
Sample <#10			62.3
% Passing #10			76.4

Hydrometer Data

Serial Number	705151
Calib. Date (mm/dd/yyyy)	12/21/2010
Low Temp (C)	17.0
Reading at Low Temp	1.0040
High Temp (C)	23.0
Reading at High Temp	1.0030
Hydrometer Cal Slope	-0.000166667
Hydrometer Cal Intercept	1.006833333
Default Soil Gravity	2.6500

Gravel/Sand Fraction (Sieves)

Sample Fraction	Size (um)	Pan Tare (g)	Pan+Sample (g)	Sample		% Finer	Classification	Sub Class
3 inch	75000			0.00	g	100.0	Gravel	
2 inch	50000			0.00	g	100.0	Gravel	
1.5 inch	37500			0.00	g	100.0	Gravel	
1 inch	25000			0.00	g	100.0	Gravel	
3/4 inch	19000			0.00	g	100.0	Gravel	
3/8 inch	9500			0.00	g	100.0	Gravel	
#4	4750	488.22	491.18	2.96	g	95.7	Gravel	
#10	2000	462.90	466.74	3.84	g	90.1	Sand	Coarse
#20	850	383.10	388.69	5.59	g	82.0	Sand	Medium
#40	425	353.37	359.88	6.51	g	72.6	Sand	Medium
#60	250	341.34	349.06	7.72	g	61.4	Sand	Fine
#80	180	330.73	335.25	4.52	g	54.9	Sand	Fine
#100	150	327.91	330.89	2.98	g	50.6	Sand	Fine
#200	75	312.22	318.87	6.65	g	41.0	Sand	Fine
				0.00	g	41.0		

Adjusted Hydrometer Sample Mass

Hydrometer Sample Mass (g)	69.1

Silt/Clay Fraction (Hydrometer Test)

Hydrometer Test Time (min)	Actual	Spec. Gravity	Temp C	Particle Size (Micron)	% Finer	Classification	Sub Class
2	2	1.0180	20.5	32.6	33.9	Silt	
5	5	1.0165	20.5	21	30.4	Silt	
15	15	1.0140	20.5	12.4	24.6	Silt	
30	30	1.0130	20.5	8.9	22.3	Silt	
60	58	1.0120	20.5	6.5	19.9	Silt	
250	256	1.0110	20.5	3.1	17.6	Clay	
1440	1440	1.0095	21.0	1.3	14.3	Clay	

DATA REPORTING QUALIFIERS

Lab Section	Qualifier	Description

QUALITY CONTROL RESULTS

Client: AECOM, Inc. Job Number: 200-12410-1

QC Association Summary

Lab Sample ID	Client Sample ID	Report Basis	Client Matrix	Method	Prep Batch
Geotechnical					
Analysis Batch:200-44120					
200-12410-1	MW-012D (14-16)	T	Solid	LAB-BUR	
Analysis Batch:200-44121					
200-12410-1	MW-012D (14-16)	T	Solid	D854	
Analysis Batch:200-44122					
200-12410-1	MW-012D (14-16)	T	Solid	D2937	
Analysis Batch:200-44297					
200-12410-1	MW-012D (14-16)	T	Solid	D422	

Report Basis
T = Total

Client:	Test America		
Project Name:	Richmond Former MGP Site		
Project Location:	---		
GTX #:	12193		
Start Date:	08/29/12	Tested By:	ema
End Date:	09/06/12	Checked By:	jdt
Boring #:	---		
Sample #:	Mw-012D (14-16)		
Depth:	---		
Visual Description:	Moist, gray sandy clay (oil residue noted on sample).		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D 5084

Constant Volume

Sample Type: tube
Permeant Fluid: De-aired Distilled water
Orientation: Vertical
Cell #: 9/7/14

Sample Preparation: Extruded from tube, cut, trimmed and placed into permeameter at as-received density and moisture content. Trimmings moisture content = 12.1%.

Parameter	Initial	Final
Height, in	3.18	2.92
Diameter, in	2.85	2.84
Area, in^2	6.38	6.33
Volume, in^3	20.3	18.5
Mass, g	672	664
Bulk Density, pcf	126	136
Moisture Content, %	15.2	13.8
Dry Density, pcf	109	120
Degree of Saturation, %	---	96

B COEFFICIENT DETERMINATION

Cell Pressure, psi: 95.1
Pressure Increment, psi: 5.10
Sample Pressure, psi: 90.0
B Coefficient: 0.95

FLOW DATA

Date	Trial #	Pressure, psi		Manometer Readings			Elapsed Time, sec	Gradient	Permeability K, cm/sec	Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
		Cell	Sample	Z_1	Z_2	Z_1-Z_2						
9/5	1	90	85	11.0	10.5	0.5	67	18.7	3.1E-07	20	1.000	3.1E-07
9/5	2	90	85	11.0	10.5	0.5	72	18.7	2.9E-07	20	1.000	2.9E-07
9/5	3	90	85	11.0	10.5	0.5	74	18.7	2.8E-07	20	1.000	2.8E-07
9/5	4	90	85	11.0	10.5	0.5	83	18.7	2.5E-07	20	1.000	2.5E-07

PERMEABILITY AT 20° C: 2.9 x 10^{-7} cm/sec (@ 5 psi effective stress)

Chain of Custody Record

TAL-4124 (1007)

Temperature on Receipt ______

Drinking Water? Yes ☐ No ☒

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

Client: AECOM	Project Manager: Nathan Conniff nathan.conniff@aecom.com	Date: 8/20/12	Chain of Custody Number: 201418
Address: 8902 Vincennes Circle, Ste.D	Telephone Number (Area Code)/Fax Number: 317-735-3021	Lab Number	Page 1 of 1
City: Indianapolis · State: IN · Zip Code: 46268	Site Contact: Nathan Conniff · Lab Contact: Ron Misiunas	Analysis (Attach list if more space is needed)	
Project Name and Location (State): Richmond MGP	Carrier/Waybill Number: Fed Ex		Special Instructions/ Conditions of Receipt
Contract/Purchase Order/Quote No.			

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix: Air	Aqueous	Sed.	Soil		Containers & Preservatives: Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc/ NaOH	Grain Size	Porosity	Permeability	Special Instructions/ Conditions of Receipt
MW-012D (14-16)	8/16/12	1802				X		1						X	X	X	

Possible Hazard Identification: ☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☒ Other Standard

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished By: [signature]	8/20/12	1000	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: WHITE - Returned to Client with Report; CANARY - Stays with the Sample; PINK - Field Copy

FedEx Express US Airbill

FedEx Tracking Number 8735 1392 8682

Form ID No. 0215

1 From This portion can be removed for Recipient's records.

Date | FedEx Tracking Number 873513928682

Sender's Name | Phone

Company

Address | Dept/Floor/Suite/Room

City | State | ZIP

2 Your Internal Billing Reference

3 To

Recipient's Name | Phone

Company

Address

We cannot deliver to P.O. boxes or P.O. ZIP codes.

HOLD Weekday — FedEx location address REQUIRED. NOT available for FedEx First Overnight.

HOLD Saturday — FedEx location address REQUIRED. Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.

Address

Use this line for the HOLD location address or for continuation of your shipping address.

City | State VT | ZIP

8735 1392 8682

4a Express Package Service *To most locations. — *Packages up to 150 lbs.*

- ☐ FedEx Priority Overnight — Next business morning.* Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- ☑ FedEx Standard Overnight — Next business afternoon.* Saturday Delivery NOT available.
- ☐ FedEx First Overnight — Earliest next business morning delivery to select locations.*
- ☐ FedEx 2Day — Second business day.* Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- ☐ FedEx Express Saver — Third business day.* Saturday Delivery NOT available.

4b Express Freight Service **To most locations. — *Packages over 150 lbs.*

- ☐ FedEx 1Day Freight — Next business day.** Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected. FedEx 1Day Freight Booking No.
- ☐ FedEx 2Day Freight — Second business day.** Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- ☐ FedEx 3Day Freight — Third business day.** Saturday Delivery NOT available.

5 Packaging *Declared value limit $500.

- ☐ FedEx Envelope*
- ☐ FedEx Pak* — Includes FedEx Small Pak and FedEx Large Pak.
- ☐ FedEx Box
- ☑ FedEx Tube
- ☐ Other

6 Special Handling and Delivery Signature Options

- ☐ SATURDAY Delivery — NOT available for FedEx Standard Overnight, FedEx Express Saver, or FedEx 3Day Freight.
- ☐ No Signature Required — Package may be left without obtaining a signature for delivery.
- ☐ Direct Signature — Someone at recipient's address may sign for delivery. *Fee applies.*
- ☐ Indirect Signature — If no one is available at recipient's address, someone at a neighboring address may sign for delivery. For residential deliveries only. *Fee applies.*

Does this shipment contain dangerous goods?

One box must be checked.

- ☑ No
- ☐ Yes — As per attached Shipper's Declaration.
- ☐ Yes — Shipper's Declaration not required.
- ☐ Dry Ice — Dry Ice, 9, UN 1845 ____ x ____ kg
- ☐ Cargo Aircraft Only

Dangerous goods (including dry ice) cannot be shipped in FedEx packaging or placed in a FedEx Express Drop Box.

7 Payment *Bill to:*

Enter FedEx Acct. No. or Credit Card No. below.

- ☑ Sender — Acct. No. in Section 1 will be billed.
- ☐ Recipient
- ☐ Third Party
- ☐ Credit Card
- ☐ Cash/Check

[redacted]

Total Packages | Total Weight ____ lbs | Credit Card Auth.

†Our liability is limited to $100 unless you declare a higher value. See the current FedEx Service Guide for details.

605

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fedex.com 1.800.GoFedEx 1.800.463.3339

Login Sample Receipt Checklist

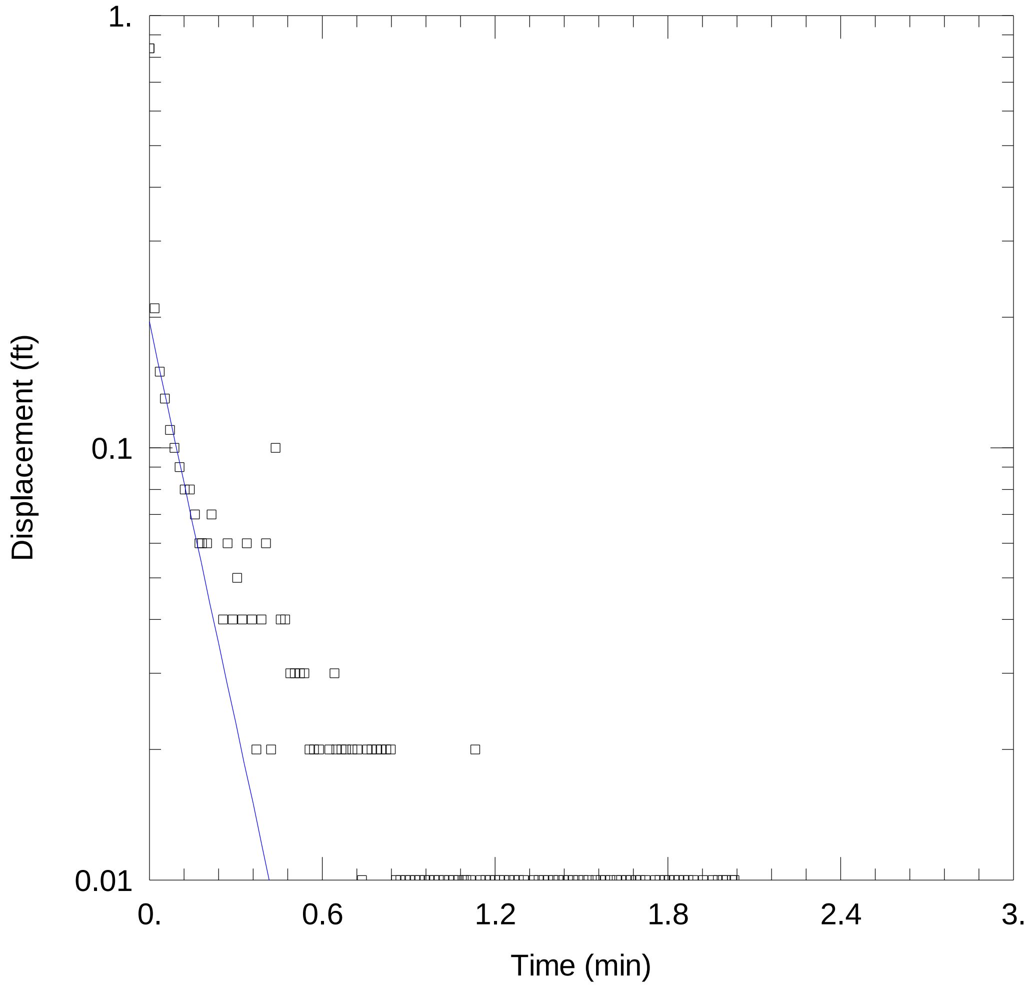
Client: AECOM, Inc. Job Number: 200-12410-1

Login Number: 12410 **List Source: TestAmerica Burlington**
List Number: 1
Creator: Kirchner, Benjamin

Question	Answer	Comment
Radioactivity either was not measured or, if measured, is at or below background	N/A	Lab does not accept radioactive samples.
The cooler's custody seal, if present, is intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	N/A	Thermal preservation not required.
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	23.0ºC, IR GUN ID 176, CF -0.8
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the sample IDs on the containers and the COC.	True	
Samples are received within Holding Time.	True	
Sample containers have legible labels.	False	Refer to Job Narrative for details.
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
VOA sample vials do not have headspace or bubble is <6mm (1/4") in diameter.	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Appendix C

Hydraulic Conductivity Test Results



FALLING HEAD

Data Set: C:\Users\wolfm\Documents\Richmond MGP\Falling head3.aqt
Date: 09/17/12 Time: 08:39:47

PROJECT INFORMATION

Company: AECOM
Test Well: MW-10

AQUIFER DATA

Saturated Thickness: 30. ft Anisotropy Ratio (Kz/Kr): 0.1

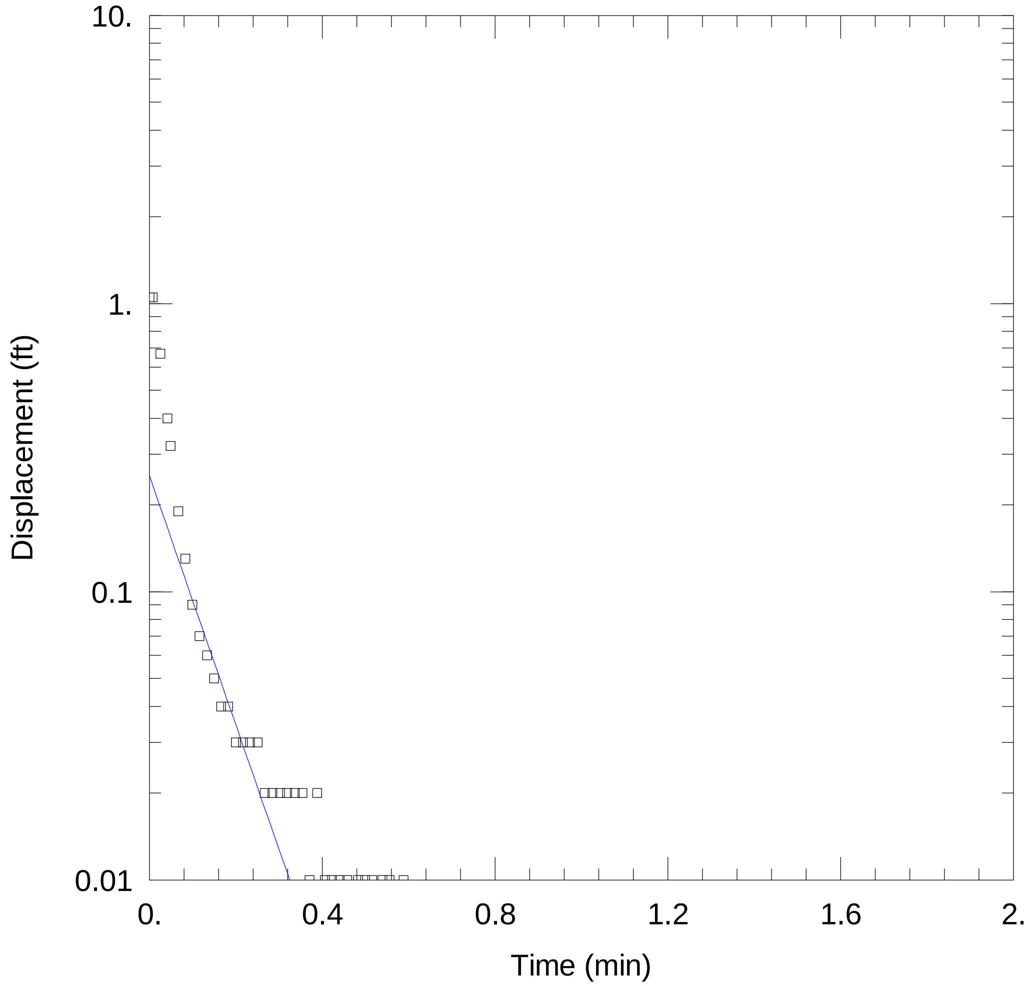
WELL DATA (MW-10)

Initial Displacement: 0.84 ft
Total Well Penetration Depth: 9.38 ft
Casing Radius: 0.083 ft
Static Water Column Height: 9.38 ft
Screen Length: 10. ft
Wellbore Radius: 0.17 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 24.71 ft/day y0 = 0.1952 ft



RISING HEAD

Data Set: C:\Users\wolfm\Documents\Richmond MGP\Risinghead2.aqt
Date: 09/17/12 Time: 08:39:14

PROJECT INFORMATION

Company: AECOM
Test Well: MW-10

AQUIFER DATA

Saturated Thickness: 30. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW-10)

Initial Displacement: 1.05 ft
Total Well Penetration Depth: 9.38 ft
Casing Radius: 0.083 ft
Static Water Column Height: 9.38 ft
Screen Length: 10. ft
Wellbore Radius: 0.17 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 34.5 ft/day y0 = 0.2528 ft

Appendix D

Analysis of Brownfield Cleanup Alternatives

ANALYSIS OF BROWNFIELD CLEANUP ALTERNATIVES

U.S. EPA Brownfield
American Recovery and Reinvestment Act of 2009 (ARRA) Revolving Loan Fund (RLF) Assistance Amendment (AA)# 2B-00E96801-2
and RLF AA# BL-00E48101-4
Indiana Brownfields Program
And
U.S. EPA Brownfield Cleanup CA# BF-00E61501
City of Richmond
for the
Former Richmond Gas Plant (a.k.a. MGP)
16 East Main Street
Richmond, Indiana
Indiana Brownfields Program
September 2012

This Analysis of Brownfield Cleanup Alternatives (ABCA) was prepared in cooperation among the Indiana Brownfields Program (Program), the City of Richmond (City), and AECOM as a requirement for utilizing United States Environmental Protection Agency (U.S. EPA) Revolving Loan Fund (RLF) and Cleanup monies to remediate a brownfield. This ABCA presents three remedial alternatives considered to mitigate potential exposure to affected **soil** at the Former Richmond Gas Plant site in Richmond, Indiana (Site). This ABCA and associated funding pertain only to source removal activities at the Site. Additional Site remediation activities are being contemplated and will be addressed in future, separate documentation. Remedial measures to address impacted source soil are anticipated to be completed in 2012. This ABCA focuses on the Site information pertinent to the property that was once the western portion of the Richmond former manufactured gas plant (MGP). This ABCA includes Site details, a summary of remedial alternatives, a summary of previous Site activities, remedial action objectives, the analysis of remedial alternatives and the selected site remedy. The vacant, vegetated Site is designated industrial with anticipated recreational re-use.

<u>Site Details</u>

Site Name:	Richmond Gas Plant (MGP) 16 East Main Street Richmond, Indiana
Property Owner:	City of Richmond Department of Metropolitan Development 50 North 5th Street Richmond, IN 47374
Site Representative:	Mr. Tony Foster Executive Director City of Richmond

Summary of Remedial Alternatives for Soil

1. Alternative 1 – Institutional control to restrict future land use to recreational.

2. Alternative 2 – Stabilization with soil additive material to encapsulate and immobilize contaminants.

3. Alternative 3 – Source material removal and disposal.

Summary of Previous Site Activities

Site investigations have been performed to delineate soil and groundwater impacts associated with the Site through means of records searches, subsurface structure identification, local hydrogeological investigations, surface and subsurface sampling, installation of groundwater monitoring wells, and laboratory analysis of soil and groundwater samples. The results and findings from previous investigation efforts were presented in a number of previously prepared documents and are summarized below. A list of documents prepared of the Site is provided in a subsequent section. Investigation activities to characterize and define the nature and extent of MGP related residuals were conducted in multiple iterations between 1994 and 2012 and are summarized below.

Subsurface structures identified during these investigation activities include a gas holder, tar well and multiple building foundations associated with historic gas plant activities. An existing basement is located in the south central portion of the Site which contains a shallow well in its base, approximately 8 feet below grade. An abandoned tunnel or cistern, presumably utilized for the City of Richmond's historical sewer system was also identified during the investigation activities. Removal of residual tar material from the well in the basement, backfilling of the basement and removal of impacted water from the onsite tunnel/cistern are included in this source removal project.

Constituents of concern (COCs) identified in the soil during previous investigations include: benzene, ethylbenzene, and xylenes; benzo(a)- anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene and, total and WAD cyanide. Source areas of this material were located in the vicinity of the tar well in the northwest portion of the Site and in the vicinity of one soil boring located in the northeastern corner of the Site. A third source area was identified during test pitting activities in 2012. This ABCA pertains to the removal of these source materials from the Site to reduce COC impacts to below Indiana Department of Environmental Management (IDEM) Risk Integrated System of Closure (RISC) levels.

Environmental Investigations Conducted at the Site Include the Following:

- Preliminary Assessment. The Preliminary Assessment (PA) was completed by RETEC in August 1993 and concluded that below-grade structures may contain MGP residuals.

- Site Inspection. A Site Inspection report was completed by RETEC in October of 1995 addressing evaluation of the vertical and horizontal extent of MGP residuals in subsurface soils. During the investigation, 22 soil borings were completed, four of which were converted to monitoring wells MW-1 through MW-4. A concrete structure was encountered during the advancement of soil boring SB-A, and several attempts were made within an area of approximately 20 square feet to install the boring; however, at a depth of approximately seven feet auger refusal occurred. Soil boring observations indicated that the uppermost water bearing unit is located at approximately 13 to 21 feet below ground surface (bgs). Soil borings generally indicate that a four to ten foot layer of fill material extends across the Site, underlain by four to ten feet of silty sand and clay, underlain by bedrock. Generally, two soil samples were collected from each soil boring and analyzed for benzene, tolulene, ethylbenzene, and total xylenes (BTEX), polynuclear aromatic hydrocarbons (PAHs), and total cyanide. One soil sample was collected from soil borings SB-5 and SB-13, and three soil samples were collected from SB-20. COCs including benzene, benzo(a)- anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene constituent concentrations were detected in soil samples SB-13, SB-14, and SB-20. Slug Testing. A Slug Testing Site Inspection was conducted by RETEC in February 1995 addressing additional hydrogeologic data from the upper-most-water-bearing unit at the Site.

- Additional Site Investigation. An Additional Site Investigation was completed by RETEC in October 1995 to evaluate the lateral extent of soil and groundwater impacts toward the Whitewater River. During the investigation, two soil boring/monitoring wells were installed (MW-101 and MW-102). Constituents detected included PAHs in soil, and ethylbenzene, total xylenes, PAHs, and total cyanide in groundwater.

- Surface Soil Sampling. In 1996, RETEC completed a surface soil investigation to assess the impact of MGP residuals at the Site. Samples were collected at twelve locations across the Site (SS-1 through SS-12).

- Ground Water Monitoring. In 1996, RETEC collected a groundwater sample from monitoring well MW-102. The remaining wells were not sampled due to the presence of product observed during collection of static water levels.

- Remediation of Purifier Parcel. In 2005, RETEC completed a soil remediation on the Purifier parcel located adjacent to the eastern boundary of the Site. During the remediation, three test pits were completed within the northwest portion of the subject Site in the area of the tar well. The first two test pits (TP-01 and TP-02) were completed to a depth of approximately 15 feet. Both test pits found no indications of a tar well. The soil from the test pits had no visual staining and the PID readings of screened soil were 0.0 ppm. The third test pit, TP-03, located approximately 20 feet west of TP-01 and TP-02, was completed to a depth of approximately 9 feet. At 9 feet a large piece of concrete, approximately 4 feet by 3 feet and a thickness of 6 inches, was exposed and lifted by the excavator. Under the exposed piece of concrete was a structure containing water and a tar-like material. The concrete appeared to be covering the structure; however, only a portion of the structure was exposed, and no estimate of structure size could be determined. The concrete was put back in place and the soil replaced into the test pit. Visual staining was observed on the soil from TP-03 at a depth of approximately 7 feet.

- Supplement Subsurface Investigation. In 2007 Burgess and Niple conducted a subsurface investigation was conducted to: investigate and define the former 65,000 and 10,000 cubic foot (cf) gas holders, delineate subsurface tar byproduct left from historical manufactured gas plant operations, and evaluate potential groundwater impact on the Site due to historical manufactured gas plant operations. The investigation included completion of two test pits, installation of two monitoring wells (MW-05 and MW-06) and completion of seven soil borings. Soil samples were collected from test pits completed in each holder. No other samples were collected.

- Phase II Investigation. A Phase II Site Investigation (Phase II) was conducted by Keramida Inc. in May 2011. The investigation activities included soil borings, monitoring well installation, monitoring well gauging and sampling of soil and groundwater. Surface soil and subsurface soil samples were collected for analysis of BTEX, PAHs, total cyanide, weak acid dissociable (WAD) cyanide, and select metals. Groundwater samples were collected for analysis of BTEX, PAHs, WAD cyanide, and select metals.

Previous Reports

The following documents have been prepared to summarize investigation activities described above at the Site:

- Preliminary Assessment, Former Manufactured Gas Plant Site, Richmond, Indiana. August 15, 1994 [PA] (RETEC, 1994).

- Site Inspection Report, Former Manufactured Gas Plant Site, Richmond, Indiana. March 31, 1995 [SI] (RETEC, 1995a).

- Slug Testing Report, Site Inspection, Former Manufactured Gas Plant Site, Richmond, Indiana. March 31, 1995 (RETEC, 1995b).

- Additional Site Investigation Report, Former Manufactured Gas Plant Site, Richmond, Indiana. January 12, 1996 (RETEC, 1996a).

- Surface Soil Sampling Report, Former Manufactured Gas Plant Site, Richmond, Indiana. May 31, 1996 (RETEC, 1996b).

- Ground Water Monitoring Summary, April 1996, Former Manufactured Gas Plant, Richmond, Indiana. June 21, 1996 (RETEC, 1996c).

- Soil Boring and Analytical Summary – December 2004, Former MGP Site – Richmond, Indiana, RETEC Project Number # IGC20-18598. Letter Report. February 16, 2005.(RETEC, 2005a).

- Supplemental Site Investigation Work Plan, Former Manufactured Gas Plant Site, Western Parcel (Main Process Area), Richmond, Indiana. May 26, 2005. (The RETEC Group, Inc., 2005b).

- State of Indiana Department of Natural Resources Division of water, Early Coordination/Environmental Assessment. DNR# ER-11607. Letter Correspondence. July 13, 2005. (IDNR, 2005).

- Remediation Completion Report, Purifier Parcel – Richmond MGP, Richmond, Indiana. August 18, 2005. (RETEC, 2005c).

- Supplement Subsurface Investigation, Former Manufactured Gas Plant, Richmond, Indiana. Letter Report. April 20, 2007. (Burgess and Niple, 2007).

- Phase II Investigation Report, Former Manufactured Gas Plant, 77 Johnson Street, Richmond, Indiana. June 11, 2011. (Keramida Inc., 2011).

Remedial Action Objectives

The Site currently is vacant and its cover is predominately fill material and dense vegetation. *See* Figures 1 and 2. Current Site use is designated industrial with anticipated future use designated as recreational. The remedial objective for the Site is to ensure that exposure to affected media is controlled sufficiently to protect future receptors: construction workers and recreational patrons.

Remedial action needed to protect potential receptors within the Site by reducing the source area contaminant levels to below IDEM RISC levels should include the following:

- Removal of MGP source material that is present in onsite areas that could potentially migrate into offsite media; and

- Eliminate or control potential exposure pathways for site workers, construction workers, and recreational patrons.

An analysis of alternatives to achieve these objectives is presented below followed by the selected remedial recommendation for the Site.

Analysis of Alternatives

Cleanup alternatives considered to mitigate exposure to affected **soil** included the following:

4. Alternative 1 – Institutional control to restrict future land use to recreational.

5. Alternative 2 – Stabilization with soil additive material to encapsulate and immobilize contaminants.

6. Alternative 3 – Source material removal and disposal.

The remedial action alternatives considered were evaluated using the following criteria:

(1) Effectiveness

   a. The degree to which the toxicity, mobility and volume of the contamination is expected to be reduced.

   b. The degree to which a remedial action option, if implemented, will protect public health, safety and welfare and the environment over time.

   c. Taking into account any adverse impacts on public health, safety and welfare and the environment that may be posed during the construction and implementation period until case closure.

(2) Implementability

a. *The technical feasibility of constructing and implementing the remedial action option at the site or facility.*

b. *The availability of materials, equipment, technologies and services needed to conduct the remedial action option.*

c. *The administrative feasibility of the remedial action option, including activities and time needed to obtain any necessary licenses, permits or approvals; the presence of any federal or state, threatened or endangered species; and the technical feasibility of recycling, treatment, engineering controls, disposal or naturally occurring biodegradation; and the expected time frame needed to achieve the necessary restoration*

(3) Cost

a. *The following types of costs are generally associated with the remedial action options.*

b. *Capital costs, including both direct and indirect costs; b. Initial costs, including design and testing costs.*

c. *Annual operation and maintenance costs.*

<u>Alternative 1 – Institutional Controls</u>

Institutional Controls; the City does not directly address impacted soil and groundwater on the Site, other than complying with Environmental Restrictive Covenants (ERCs) to limit land use to commercial/industrial and installing a permanent fence to isolate the impacted Site.

1. Effectiveness – If soils exceeding the IDEM Industrial Default Closure Levels (IDCL) and/or recreational exposure levels are encountered, then this alternative would not protect construction workers during subsurface excavation work or the general public utilizing the Site for its intended recreational purposes. Fencing the Site would help mitigate this exposure. However, due to the continued exposure potential, this alternative is not an effective stand-alone remedial alternative.

2. Implementability- Easy to implement in the short term. No long-term protection of construction workers or public.

3. Cost – less than $10,000. All capital costs. No operation and maintenance (O&M) costs.

<u>Alternative 2 – In-situ Solidification</u>

In-situ solidification (ISS) is the process of solidifying the COCs by mixing in Portland cement and other additives, if needed. By solidifying the COCs and reducing the permeability, groundwater will flow around the solid soil area rather than through it helping to prevent the spread and movement of contamination. Mixing can be completed with the use of augers, injection rakes or with an excavator bucket, depending on depth and soil conditions.

1. Effectiveness – Contaminant mass would be sequestered but not destroyed. This alternative is very effective as COCs would no longer be mobile in the soil and not be able to impact groundwater.

2. Implementability – The mixing of solidification agent with the impacted soil is relatively easy. There may be an airborne dust issue during mixing operations which could be controlled with the addition of dust suppressant during mixing activities.

3. Cost – In-situ Solidification ($450,000) is more costly than taking no action and for excavation and offsite disposal of source material soils. It would be comparable in cost to capping the Site. All capital costs. No O&M costs.

Alternative 3 – Source Material Removal and Disposal

Removal and disposal of all impacted soil above IDEM RISC levels.

1. Effectiveness – This option would permanently remove potential COC sources in excess of the construction worker limits.

2. Implementability – The removal action is relatively simple, although some preliminary investigation will be necessary to delineate the source materials.

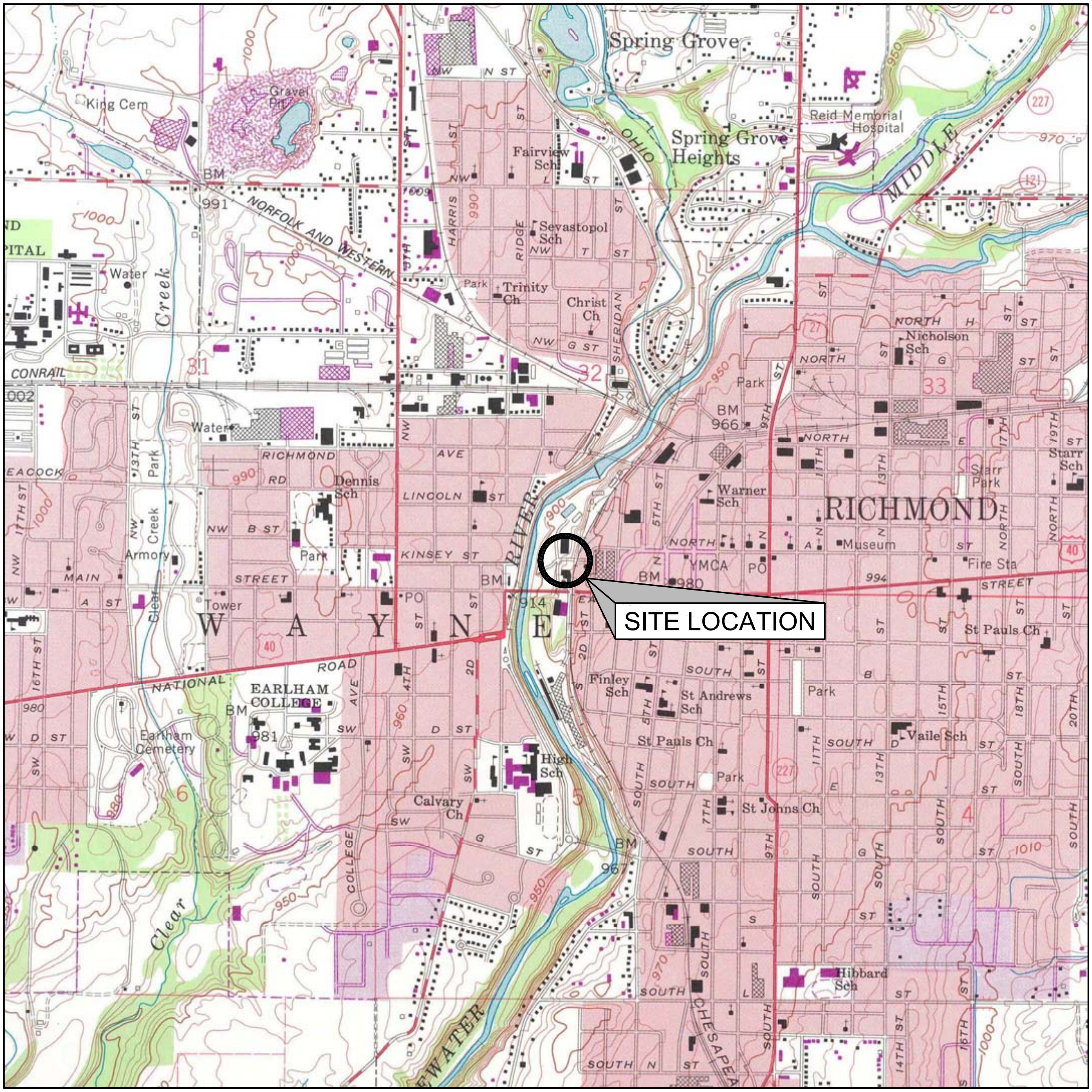
3. Cost – Source material removal ($160,000) would be the most cost effective option with the exception of institutional controls. All capital costs. No O&M costs.

Recommendation for Site Remedy

Alternative 1 (Institutional Controls) is a cost effective and accepted measure to manage risk by limiting future Site use to a narrow receptor group. Alternative 2 (In-situ Solidification) in conjunction with some form of capping and institutional control would adequately prevent exposure and off-site migration but would be significantly more expensive than source removal and may limit future development opportunities due to the remaining monolith. Alternative 3 (Source Material Removal and Disposal) is the most cost effective option and permanently removes the potential direct contact with source material(s) and the potential for migration to groundwater. Therefore, the recommended remedy is a combination of institutional controls (Alternative 1) and contaminant removal (Alternative 3).

Decision Document

A decision document will be issued at the close of the public comment period with additional details on the selected alternative for site remedy. The decision document will serve as a notice to proceed with federally funded remediation activities and will be available in the local information repository for public view, along with this Site ABCA and other Site-related documents for public view.



BASE TAKEN FROM USGS RICHMOND, IND.
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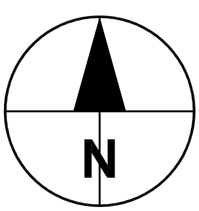
DATE 1981. SCALE 1:24,000.



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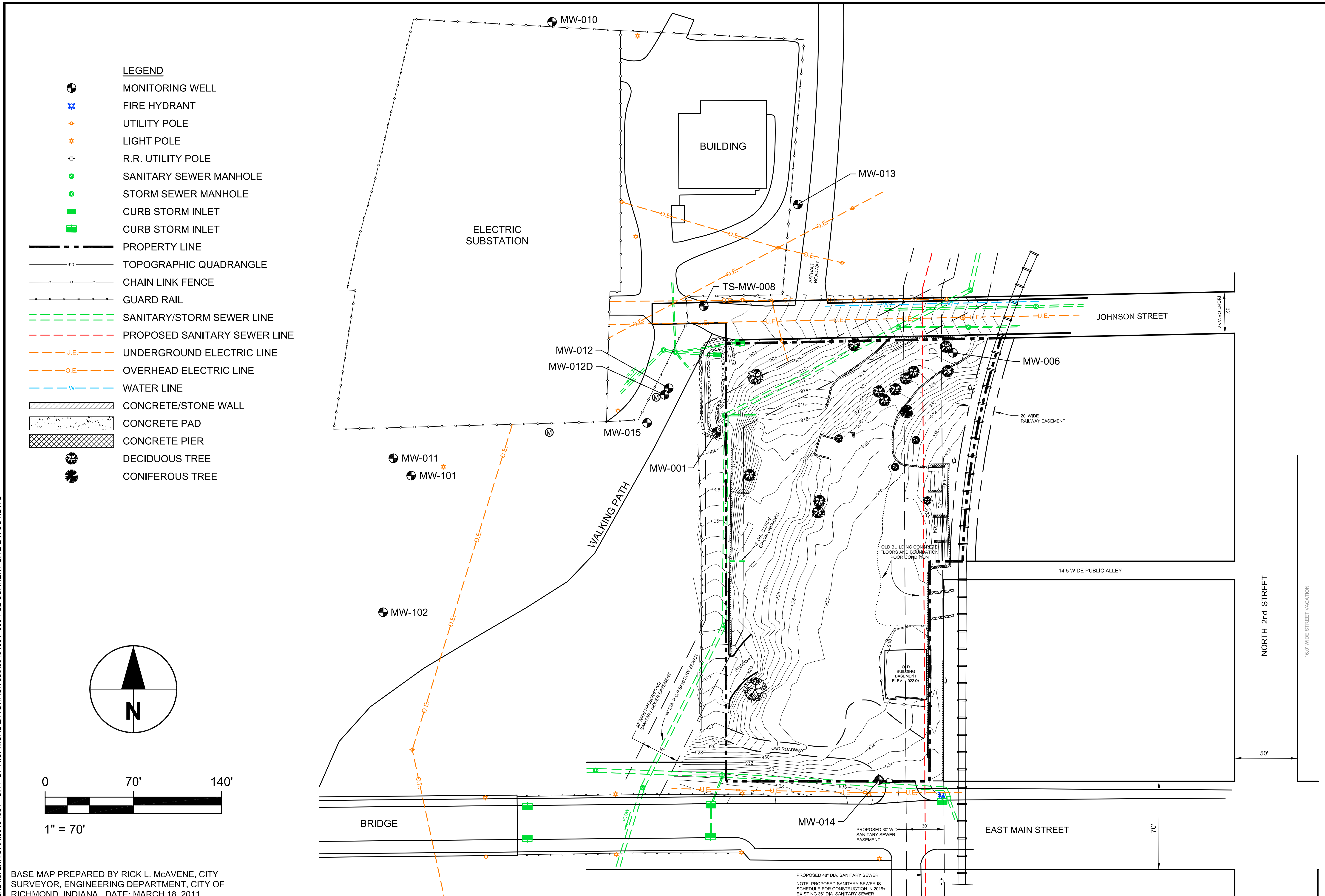
FORMER MGP SITE
RICHMOND, INDIANA

SITE LOCATION MAP

AECOM

Project No.: 60194081 Date: 2012-09-20

Figure: 1



BASE MAP PREPARED BY RICK L. McAVENE, CITY SURVEYOR, ENGINEERING DEPARTMENT, CITY OF RICHMOND, INDIANA. DATE: MARCH 18, 2011.

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Approved:
Checked: NC
Designer: NLW
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AECOM

Figure: 2

CURRENT SITE LAYOUT

FORMER MGP SITE
RICHMOND, INDIANA

Project No.: 60194081 Date: 2012-09-20

Appendix E

Site-Specific Health and Safety Plan

HEALTH AND SAFETY PLAN

Richmond Gas Plant
16 East Main Street
Richmond, Indiana
Brownfields No. 4980004

Prepared for:

City of Richmond
Department of Metropolitan Development
50 North 5th Street
Richmond, IN 47374

Prepared by:

AECOM
1800 W. 17th Street, Suite A
Bloomington, IN 47404

Health and Safety Plan Expiration Date:

Project No: 60194081

Project Health and Safety Plan

This project Health and Safety Plan (HASP) was prepared for employees performing a specific, limited scope of work. It was prepared based on the best available information regarding the physical and chemical hazards known or suspected to be present on the project site. While it is not possible to discover, evaluate, and protect in advance against all possible hazards, which may be encountered during the completion of this project, adherence to the requirements of the HASP will significantly reduce the potential for occupational injury.

By signing below, I acknowledge that I have reviewed and hereby approve the HASP for the Richmond Former MGP site. This HASP has been written for the exclusive use of AECOM, its employees, and subcontractors. The plan is written for specified site conditions, dates, and personnel, and must be amended if these conditions change.

Prepared by:

Katie Dubec

Katie Dubec
Project Geologist
812-334-8304

September 23, 2011
Date

Concurrence by:

Brett D. Hodgson

Brett D. Hodgson, CSP
Regional SH&E Manager
616-940-4444

September 23, 2011
Date

Approved by:

Jeffy P. Nelson

Jeffrey Nelson
Project Manager
812-334-8311

September 23, 2011
Date

Executive Summary

The purpose of this Health and Safety Plan (HASP) is to address health and safety concerns related to AECOM managed activities at the Richmond Former MGP site, located in Richmond, Indiana. The specific roles, responsibilities, authority, and requirements as they pertain to the safety of employees and the scope of services are discussed herein. The document is intended to identify known potential hazards and facilitate communication and control measures to prevent injury or harm. Additionally, provisions to control the potential for environmental impact from these activities are included where applicable.

Environmental services being performed at the site include, but are not limited to:

- Mobilization/demobilization
- Site Preparation
- Clearing/Grubbing
- Well installation/Monitoring
- Drilling/Geoprobe
- Soil/Sediment Sampling
- Ground Water Sampling
- Excavation Oversight
- IDW Management
- Equipment Decontamination
- Site Restoration

The primary physical hazards which may be encountered include:

- Slips, Trips, Falls, and Protruding Objects
- Housekeeping
- Manual Lifting
- Utilities
- Heavy Equipment and Vehicle Operations
- Drilling Operations
- Excavations
- Dust
- Noise

The chemical hazards which may be encountered include:

- Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Metals
- Cyanide

All staff are bound by the provisions of this HASP and are required to participate in a preliminary project safety meeting to familiarize them with the anticipated hazards and respective onsite controls. The discussion will cover the entire HASP subject matter, putting emphasis on critical elements of the plan; such as the emergency response procedures, personal protective equipment, site control strategies, and monitoring requirements. In addition, daily tailgate safety meetings will be held to discuss: the anticipated scope of work, required controls, identify new hazards and controls, incident reporting, review the results of inspections, any lessons learned or concerns from the previous day.

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ATTACHMENTS

1.0 Introduction

This Health and Safety Plan (HASP) (including **Attachments A**-**C**) provides a general description of the levels of personal protection and safe operating guidelines expected of each employee or subcontractor associated with the environmental services being conducted at the Richmond Former MGP site, located in Richmond, Indiana. This HASP also identifies chemical and physical hazards known to be associated with the AECOM-managed activities addressed in this document.

HASP Supplements will be generated as necessary to address any additional activities or changes in site conditions, which may occur during field operations.

1.1 General

The provisions of this HASP are mandatory for all AECOM personnel engaged in fieldwork associated with the environmental services being conducted at the subject site. A copy of this HASP, any applicable HASP Supplements and the AECOM's North America Safety, Health, and Environmental (SH&E) Procedures and Manual shall be accessible on site and available for review at all times. Record keeping will be maintained in accordance with this HASP and the applicable Standard Operating Procedures (SOPs). In the event of a conflict between this HASP, the SOPs and federal, provincial, state, and local regulations, workers shall follow the most stringent/protective requirements. Concurrence with the provisions of this HASP is mandatory for all personnel at the site covered by this HASP and must be signed on the acknowledgement page.

1.2 Project Policy Statement

AECOM is committed to protecting the safety and health of our employees and meeting our obligations with respect to the protection of others affected by our activities. We are also committed to protecting and preserving the natural environment in which we operate. The safety of persons and property is of vital importance to the success of this project and accident prevention measures shall be taken toward the avoidance of needless waste and loss. It shall be the policy of this project that all operations be conducted safely. Onsite supervisors are responsible for those they supervise by maintaining a safe and healthy working environment in their areas of responsibility, and by fairly and uniformly enforcing safety and health rules and requirements for all project personnel. Subcontractors shall comply with the requirements of this HASP, provisions contained within the contract document and all applicable rules, requirements and health, safety and environmental regulations. All practical measures shall be taken to promote safety and maintain a safe place to work. Contractors are wholly responsible for the prevention of accidents on work under their direction and shall be responsible for thorough safety and loss control programs and the execution of their own safety plans for the protection of workers.

1.3 References

This HASP conforms to the regulatory requirements and guidelines established in the following documents:

- Title 29, Part 1910 of the Code of Federal Regulations (29 CFR 1910), Occupational Safety and Health Standards (with special attention to Section 120, Hazardous Waste Operations and Emergency Response).
- Title 29, Part 1926 of the Code of Federal Regulations (29 CFR 1926), Safety and Health Regulations for Construction.
- National Institute for Occupational Safety and Health (NIOSH)/OSHA/U.S. Coast Guard (USCG)/EPA, Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, Publication No. 85-115, 1985.

2.0 Site Information and Scope of Work

AECOM will conduct environmental services at the Richmond Former MGP site. Work will be performed in accordance with the applicable Statement of Work (SOW) and associated Project Work Plan developed for project site. Deviations from the listed SOW will require that a Safety Professional review and changes made to this HASP, to ensure adequate protection of personnel and other property.

The following is a summary of relevant data concerning the project site, and the work procedures to be performed. The Project Work Plan prepared by AECOM as a companion document to this HASP provides more detail concerning both site history and planned work operations.

2.1 Site Information

Site information including a general description of the site, background and history and a summary of previous investigations is provided in Section 1.0 of the Removal Action Work Plan (RAWP) and summarized below.

The former MGP site originally covered an area of 2.26 acres and has been divided into three separate parcels since cessation of MGP operations. The eastern and central parcels, covering 0.44 and 0.38 acres respectively, are owned by the Indiana Gas Company (IGC) and are located east of the C & O Railroad. The western parcel (Site), covering 1.429 acres, is owned by the City of Richmond. The Site is located on the southwest corner of Johnson Street and North 2nd Street in Richmond, Wayne County, Indiana. The location of the Site is shown in Figure 1 of the RAWP.

The Site is bounded by the following:

- To the north by Johnson Street.
- To the east, by railroad tracks beyond which are the two parcels owned by IGC/Vectren;
- To the south by East Main Street. Commercial property is located south of East Main Street.
- To the west by a vacant lot covered with grass-like vegetation owned by the City of Richmond.

All buildings on the Site were demolished in 2009. The Site currently is vacant and heavily vegetated. The site layout is shown in Figure 2 of the RAWP. Land use on adjacent properties is characterized as nonresidential. The nearest surface water body is the East Fork of the Whitewater River, located about 400 feet west of the Site. General surface topography of the site slopes to the west.

<u>Historical Summary</u>

The Richmond MGP began production of gas using the coal carbonization process in approximately 1855. During 1882 and 1883, the plant was rebuilt and equipped with new machinery, and converted to the carbureted water gas process some time after. Between 1896 and 1901 the CR&M Railroad was granted a right-of-way, and the track separated the western and eastern portions of the former MGP. By 1909, the 320,000 cubic feet capacity gas holder was added to the eastern portion of the former MGP (the eastern portion of the former MGP is not the subject of this RAWP). Gas manufacturing was put on standby for a period, and natural gas was distributed through its mains until November 1924, at which time the company again began to manufacture gas. The plant operated intermittently until approximately 1941. The remaining two gas holders, located in the southwestern portion of the former MGP (located on the subject Site), had capacities of 65,000 and 10,000 cubic feet. Other former MGP structures located on the subject Site included: a tar well, coal shed, retorts, generator room and meter room.

<u>Past and Current Operations</u>

Figure 3 of the RAWP shows the locations of former MGP structures including two gas holders (65,000 cubic feet and 10,000 cubic feet), a tar well, coal sheds, retorts, a generator room and a meter room. In addition, beneath the former MGP building easement there are two brick tunnels that contain tar along the bottom.

All remaining above ground structures on the Site were demolished in 2009. The Site currently is vacant and is heavily vegetated in most portions. The City of Richmond is planning to redevelop the Site and include it as part of a recreational pedestrian and bicycle trail.

<u>Previous Investigations Conducted at the Site</u>

Site investigations have been performed to delineate soil and ground water impacts associated with the former Richmond MGP Site through means of records searches, subsurface structure identification, local hydrogeological investigations, surface and subsurface sampling, installation of groundwater monitoring wells, and laboratory analysis of soil and groundwater samples. Information and findings from previous Site investigative efforts is provided in a number of documents. It is the intent of this document to focus on the Site information pertinent to the property that was once the western portion of the Richmond former MGP.

Investigation activities were performed at the Site and the western portion of the former MGP Site between 1994 and 2011 to determine the potential for environmental impacts related to past MGP operations, and to identify the presence of MGP residuals.

Environmental Investigations conducted at the Site include the following:

- Preliminary Assessment. The Preliminary Assessment (PA) was completed by RETEC in August 1993 and concluded that below-grade structures may contain MGP residuals.
- Site Inspection. A Site Inspection report was completed by RETEC in October of 1995 addressing evaluation of the vertical and horizontal extent of MGP residuals in subsurface soils. During the investigation, 22 soil borings were completed, four of which were converted to monitoring wells MW-1 through MW-4. A concrete structure was encountered during the advancement of soil boring SB-A, and several attempts were made within an area of approximately 20 square feet to install the boring; however, at a depth of approximately seven feet auger refusal occurred. Soil boring observations indicated that the uppermost water bearing unit is located at approximately 13 to 21 feet bgs. Soil borings generally indicate that a four to ten foot layer of fill material extends across the Site, underlain by four to ten feet of silty sand and clay, underlain by bedrock.
- Generally, two soil samples were collected from each soil boring and analyzed for BTEX, PAHs, and total cyanide. One soil sample was collected from soil borings SB-5 and SB-13, and three soil samples were collected from SB-20. Benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene constituent concentrations were detected in soil samples SB-13, SB-14, and SB-20 above their respective Tier II Nonresidential Criteria. Benzene and naphthalene constituent concentrations were detected in the groundwater samples above the Tier II Nonresidential Criteria.
- Slug Testing. A Slug Testing Site Inspection was conducted by RETEC in February 1995 addressing additional hydrogeologic data from the upper-most-water-bearing unit at the Site. A detailed discussion of the hydrogeology is provided in a subsequent section of this report.
- Additional Site Investigation – 1995 An Additional Site Investigation was completed by RETEC in October 1995 to evaluate the lateral extent of soil and groundwater impacts toward the Whitewater River. During the investigation, two soil boring/monitoring wells were installed (MW-101 and -102). Constituents detected included PAHs in soil, and ethylbenzene, total xylenes, PAHs, and total cyanide in groundwater. Concentrations of all constituents were less than the Tier II Nonresidential Criteria.
- Surface Soil Sampling. In 1996, RETEC completed a surface soil investigation to assess the impact of MGP residuals at the Site. Samples were collected at twelve locations across the Site (SS-1 through SS-12).
- Ground Water Monitoring – In 1996, RETEC collected ground water samples were collected from monitoring well MW-102. The remaining wells were not sampled due to the presence of product observed during collection of static water levels.
- Remediation of Purifier Parcel – In 2005, RETEC completed a soil remediation on the Purifier parcel located adjacent to the eastern boundary of the Site. During the remediation, three test pits were completed within the northwest portion of the subject Site in the area of the tar well. The first two test pits (TP-01 and TP-02) were completed to a depth of approximately 15 feet. Both test pits found no indications of a tar well. The soil from the test pits had no visual staining and the PID readings of screened soil were 0.0 ppm. The third test pit, TP-03, located approximately 20 feet west of TP-01 and TP-02, was completed to a depth of approximately 9 feet. At 9 feet a large piece of concrete, approximately 4 feet by 3 feet and a thickness of 6 inches, was exposed and lifted by the excavator. Under the exposed piece of concrete was a structure containing water and a tar-like material. The concrete appeared to be covering the structure; however, only a portion of the structure was exposed, and no estimate of structure size could be determined. The concrete was put back in place and the soil replaced into the test pit. Visual staining was observed on the soil from TP-03 at a depth of approximately 7 feet.
- Supplement Subsurface Investigation – In 2007 Burgess and Niple conducted a subsurface investigation was conducted to: investigate and define the former 65,000 and 10,000 cubic-foot (cf) gas holders, delineate subsurface tar byproduct left from historical manufactured gas plant operations, and evaluate potential ground water impact on the Site due to historical manufactured gas plant operations. The investigation included completion of two test pits, installation of two monitoring wells (MW-05 and MW-06) and completion of seven soil borings. Soil samples were collected from test pits completed in each holder. No other samples were collected.
- Phase II Investigation. A Phase II Site Investigation (Phase II) was conducted by Keramida Inc. in May 2011. The investigation activities included soil borings, monitoring well installation, monitoring well gauging and sampling of soil and groundwater. Surface soil and subsurface soil samples were collected for analysis of BTEX, PAHs, total cyanide, weak acid dissociable (WAD) cyanide, and select metals. Ground water samples were collected for analysis of BTEX, PAHs, WAD cyanide, and select metals.

Table 1 of the RAWP provides a summary of the activities completed during each of these assessments. Results of samples collected during investigation of this Site are summarized in subsequent sections of this report.

2.2 Scope of Work

AECOM will conduct environmental services at the site. Work will be performed in accordance with the applicable Statement of Work (SOW) and associated Work Plans developed for this site.

2.2.1 Mobilization/Demobilization

Mobilization and demobilization represent limited pre- and post-task activities. These activities include driving to and from the site; initial site preparations, such as trailer and toilet facility setup; and post-work activities, such as removing files and office equipment and general housekeeping. Mobilization and demobilization do not represent any intrusive activities. Electrical hook-up and disconnect for office trailers must be performed by a licensed electrical subcontractor. Prior to mobilization, all utility clearance shall be obtained by the authorizing authority for the subject site. If utility locations cannot be verified on site by the public authority, then a private utility location contractor may need to be utilized to confirm/deny the presence of private underground utilities on the site.

2.2.2 Site Preparation

Site preparation includes construction and maintenance of temporary access roads and construction area entrances, installation of silt fence around the perimeter of disturbance areas, and installation of berms to facilitate the use of existing drainage features and structures. Other pre-work activities, such as the stockpiling of backfill materials, utility mark-out and clearance, and the setup of other work support items are included as well. Other site preparation activities will include the verification of utility mark-outs and presence of the clear dig permits (on site). Typically, the lead time for a clear dig permit is three days, and the permit is generally valid for 10 days. Consult the specific clearance dates associated with the permit obtained for the site.

2.2.3 Clearing and Grubbing

Clearing and grubbing involves the removal of trees and vegetation and their root systems. The limits of clearing and grubbing will extend approximately 10 feet beyond the perimeter of the areas specified in the work plan. Clearing will involve the cutting of standing timber and the removal of brush utilizing chainsaws, brush hogs, and chippers. Grubbing will be performed using a dozer and/or hydraulic excavator. All cut and chipped vegetative material will be placed in roll-off boxes for offsite disposal.

2.2.4 Groundwater Sampling

Groundwater sampling includes the collection of groundwater samples from existing monitoring well networks, temporary Geo-probe points, and new monitoring wells. Groundwater samples will be collected through low-flow sampling techniques using submersible pumps. During groundwater collection, appropriate air monitoring will be conducted and the appropriate chemical resistant PPE will be worn to protect against exposure. The major activities involved with collecting groundwater samples from the site and surrounding properties include the following:

- Pre-sampling event notifications and approval.
- Setup for sampling activities.
- Groundwater samples from monitoring wells collected using low-flow sampling techniques.
- Sample prep and sample shipping.
- Administrative activities.

2.2.5 Soil Sampling

Soil samples will be collected from Geo-probe points and during well installation activities. During sampling activities, appropriate air monitoring will be conducted and the appropriate chemical resistant PPE will be worn to protect against exposure. The major activities involved with collecting samples from the site and surrounding properties include the following:

- Pre-sampling event notifications and approval.
- Setup for sampling activities.
- Soil sample collection during well installation activities using HSA drilling techniques or from Geo-probe points.
- Sample prep and sample shipping.
- Administrative activities.

2.2.6 Excavation of Contaminated Soils

AECOM will excavate and dispose impacted soils off site using an excavator and direct loading into roll-off or other approved containers for off-site transportation and disposal. The impacted materials will be placed into lined/covered roll-offs and will be temporarily staged on site prior to transportation to the disposal facility. Equipment operators will be supported by a crew of technicians who will perform spotting activities, provide traffic control, the securing of roll-off containers, and general housekeeping activities on the site. Additional confirmation sampling of the excavation will be performed under this task as well.

2.2.7 Investigative-Derived Waste (IDW) Management

IDW will be collected and categorized as nonhazardous or hazardous. Potentially hazardous IDW (purge water, decontamination fluids, and soil cuttings, if any) will be tested and disposed of within 90 calendar days of completing the field activities. Potentially hazardous IDW waste will be staged onsite, then delivered to an IDW storage facility for processing. Nonhazardous IDW (normal trash) will be disposed of in a timely fashion during fieldwork. Drum handling and drum sampling activities may take place under this task.

2.2.8 Equipment Decontamination

AECOM and subcontractor personnel will perform decontamination of equipment used to perform work within controlled work areas. Decontamination procedures could range from dry-brush techniques, to wet methods (rinse/wash), to steam cleaning as determined by the type of operation being conducted. Please detail-out the anticipated decon methods for the site.

Before any drilling is begun, and at the completion of drilling, the drilling subcontractor shall decontaminate the drill rig, casing, samplers, and all other drilling equipment that will be used on site. The drilling subcontractor shall provide a high-pressure steam cleaner for decontamination of all downhole drilling equipment. The drill rig shall be steam cleaned between drilling at each site. Soil sampling equipment shall be decontaminated between each use, using a phosphate free detergent and potable water in accordance with ASTM D 5088. The drilling subcontractor shall construct a temporary decontamination pad to contain all decontamination water generated during decontamination of drill rigs and tools.

2.2.9 Site Restoration

Site restoration will involve the removal of temporary roadways and staging areas, final grading of the site, surface cover installation (asphalt and concrete placement, topsoil, seeding, mulching, tree planting, and other landscaping), removal of temporary fencing and erosion control materials, and the disposal of construction debris.

2.2.10 Additional Work Operations

Operations at the site may require additional tasks not identified in this section or addressed in **Attachment A** (THAs). Prior to performing any task not covered in this HASP a THA will be prepared, and approved by the Safety Professional.

3.0 Hazard Assessment (Safety)

3.1 Physical Hazards

3.1.1 Slips, Trips, Falls, and Protruding Objects

A variety of conditions that may exist may result in injury from slips, trips, falls, and protruding objects. Slips and trips may occur as a result of wet, slippery, or uneven walking surfaces. To prevent injuries from slips and trips, always keep work areas clean; keep walkways free of objects and debris; and report/clean up liquid spills. Serious injuries may occur as a result of falls from elevated heights. Always wear fall protection while working at heights of 6 feet or greater above the next lower level. Protruding objects are any object that extends into the path of travel or working area that may cause injury when contacted by personnel. Always be aware of protruding objects and when feasible remove the protruding object or label it with an appropriate warning.

3.1.2 Housekeeping

During site activities, work areas will be continuously policed to identify excess trash and unnecessary debris. Excess debris and trash will be collected and stored in an appropriate container (e.g., plastic trash bags, garbage can, roll-off bin) prior to disposal. At no time will debris or trash be intermingled with waste PPE or contaminated materials.

3.1.3 Manual Lifting

Most materials associated with investigation and remedial activities are moved by hand. The human body is subject to severe damage in the forms of back injury, muscle strains, and hernia if caution is not observed in the handling process. Whenever possible, use mechanical assistance to lift or move materials and, at a minimum, use at least two people to lift or roll/lift with your arms as close to the body as possible.

3.1.4 Utilities

Various forms of underground/overhead utility lines or pipes may be encountered during site activities. Prior to the start of intrusive operations, utility clearance is mandated, as is obtaining authorization from all concerned public utility department offices. If insufficient data is available to accurately determine the location of the utility lines, AECOM will hand clear to a depth of at least 5 feet below ground surface in the proposed areas of subsurface investigation. Should intrusive operations cause equipment to come into contact with utility lines, the SSO and an AECOM SH&E Professional will be notified immediately. Work will be suspended until the applicable utility agency is contacted and the appropriate actions for the particular situations can be taken. The phone number for the applicable state agency is provided in the Emergency Contacts list.

Ensure that backhoe operators, truck drivers, etc. and the signal person are aware of overhead power lines when working around overhead power lines. Overhead power and utility lines may be present on, or adjacent to, the site and represent a potential hazard during the mobilization/demobilization of equipment and supplies. Maintain a minimum of 10 feet between overhead power lines and the bucket and/or arm of the backhoe bed/cab of trucks, etc. Any deviation must be approved by the Regional SH&E Manager.

3.1.5 General Electrical Hazards

Electrical and powered equipment may be used during a variety of site activities. Injuries associated with electrical and powered equipment include electric shock, cuts/lacerations, eye damage (from flying debris), and burns. To reduce the potential of injury from the hazards associated with electrical and powered equipment, always comply with the following:

- Use ground fault circuit interrupters (GFCIs) when using electrical powered tools/equipment. GFCIs prevent electrical shock by detecting the loss of electricity from a power cord and/or electrical device.
- Confirm that generators are properly grounded, including the use of a grounding rod driven to a depth of 3 feet.
- Wear ANSI-approved (Z87.1) safety glasses. Face shields may be required to provide additional face protection from flying debris.
- Wear appropriate work gloves. Work gloves may reduce the severity of burns and cuts/lacerations.

All temporary electric installations (site trailer, subpanels) will comply with OSHA (29 CFR 1926, Subpart K, and 29 CFR 1910, Subpart S) guidelines. Only qualified and competent individuals (licensed electrician) will provide electrical service/servicing. Refer to SH&E 712, Hazardous Energy Control, for additional requirements and information.

3.1.6 Heavy Equipment and Vehicle Operations

Heavy equipment and site vehicles present serious hazards site personnel. Blind spots, failure to yield, and other situations may cause heavy equipment/vehicles to come into contact with personnel. To reduce the possibility of contact between equipment/traffic and personnel, always adhere to the following:

- Personnel must wear a high-visibility, reflective safety vest at all times when working near heavy equipment and/or other vehicle traffic.
- Personnel must always yield to equipment/vehicle traffic and stay as far as possible from all equipment/vehicle traffic. Always maintain eye contact with operators.
- When feasible, place barriers between work areas and equipment/vehicle traffic.
- Always ensure that reverse warning alarms are working and louder than surrounding noise. Personnel must report inoperative reverse warning alarms.
- Confirm Daily Equipment Safety Inspections are being performed and that documentation is filed at the site.

3.1.7 Drilling Operations

Drilling operations, including hollow-stem, rotary and/or direct push drilling, present their own set of hazards. Several basic precautions that should be taken include, but are not limited to, confirming locations of underground and overhead utilities, wearing of appropriate PPE and the avoidance of loose clothing or jewelry, staying clear of moving parts, and knowing the locations of emergency shut-off switches. Other operational safety precautions regarding moving the drilling equipment, raising and lowering the derrick (mast), and drilling may be required.

3.1.8 Excavations and Trenches

Excavations and trenches present workers with a variety of hazards. If not properly sloped, shored, or boxed, trench walls may collapse and trap workers under the weight of the soil. Soil contaminants and other chemical hazards (e.g., carbon monoxide from equipment/vehicles) may result in a hazardous atmosphere. Confined space entry procedures may need to be followed if the potential for a hazardous atmosphere exists. Buried utilities may exist where excavations/trenches will be placed. Always contact the local utility locator service prior to beginning excavations.

3.1.9 Dust and Odor Control

Specific controls will be in place to prevent dust generation. If dust is observed reaching or approaching the site boundary, activities causing the dust will be immediately stopped. Dust control measures (water spray, soil covers, slower work pace, or change in work activities) will be deployed prior to resuming work. Corrective measures will be documented in the daily report.

Because of the nature of the contaminant at the site, odors are not likely to be anticipated to be of concern. In the event that an odor complaint is received, the SS and/or SSO will immediately assess site conditions and will determine the probable cause or causes. Appropriate odor mitigation measures will be deployed. These measures may include covering sediment piles, deploying odor suppressing foam, implementing air monitoring, or discontinuing activities that are generating the odor. Corrective measures will be documented in the daily report.

3.1.10 Noise Exposure Monitoring

When heavy equipment is in operation, it will be necessary to ensure that each exclusion zone fully encompasses all areas where hazardous noise levels are present (85dBA or greater). Once each work day, the SSO will use a sound level meter to survey the perimeter of each exclusion zone while all onsite heavy equipment within the zone is being operated simultaneously. If the sound pressure level exceeds 85 dBA at any location along the site perimeter, the SSO will exit the exclusion zone and use the meter to determine the 85 dBA limit. The exclusion zone boundary will then be adjusted to fully encompass this region.

3.2 **Wildlife, Plant and Insect Hazards**

3.2.1 Small Mammals

Working in the field either directly or indirectly with small mammals has an inherent risk of injury or exposure to zoonotic diseases (infectious diseases that can be transmitted from animals to humans) against which all field staff needs to protect themselves.

This risk is usually higher when there is direct contact with a wild animal, either through a break in the skin (blood), saliva, or excrement; however, air-borne diseases (e.g., Hantavirus) also pose a risk.

Obviously, wildlife biologists directly handling wildlife, dead or alive, or working with wildlife feces or in enclosed habitats (such as caves), have an increased risk of exposure to a wider range of zoonotic diseases and should take extra precautions.

3.2.2 Venomous Animals

Some animals have the ability to inject venom. These include rattlesnakes, black widow spiders, and scorpions, all of which have limited distributions and therefore are unlikely to be encountered in most areas. Other spiders possess venom but they are not potentially lethal to humans. Shrews have poisonous saliva, but the chance of being envenomated by them is extremely unlikely unless they are handled.

If bitten by any of these animals, special care should be taken to treat the wound as it may lead to complications due to the toxin.

A bite from a venomous snake, which may inject varying degrees of toxic venom, is rarely fatal but should always be considered a medical emergency.

3.2.3 Poisonous Plants

Sensitivity to toxins generated by plants, insects, and animals varies according to dosage and the ability of the victim to process the toxin; therefore, it is difficult to predict whether a reaction will occur or how severe the reaction will be. Staff should be aware that a large number of organisms are capable of causing serious irritations and allergic reactions. Some reactions will only erupt if secondary exposure to sunlight occurs. Depending on the severity of the reaction, the result can result in severe scarring, blindness, or even death.

3.3 Radiological Hazards

No radiological hazards are present at the site.

3.4 Weather Hazards

The Site Safety Officer will be attentive to daily weather forecasts for the project area each morning. Predicted weather conditions of potential field impact are to be included in safety briefings and the Task Hazard Analysis (THA) for that day. Weather changes should initiate a review and updates (THA) as necessary.

Severe weather can occur with little warning. Employees will be vigilant for the potentials for storms, lightning, high winds, and flash flood events.

3.5 Hazard Analysis

Task Hazard Analyses (THAs) have been completed for all tasks identified in the Scope of Work (**Attachment A**).

3.5.1 Unanticipated Work Activities/Conditions

As a result of unanticipated work activities or changing conditions, additional THAs may be required. All additional THAs will be reviewed and approved by the SH&E Professional.

3.6 Task Specific SH&E Procedures

As discussed in Section 5.0, personnel may be exposed to a variety of chemical, physical, and radiological hazards resulting from task or equipment-specific activities. The controls for many of these hazards are discussed in SOPs found in the **Series 300 to 500** North America SH&E SOPs.

	SOP#	TITLE		SOP#	TITLE
S3NA 300 Series Field(Common)			**S3NA 500 Series Industrial Hygiene**		
☐	S3NA-301-PR	Confined Spaces	☐	S3NA-501-PR	Asbestos
☐	S3NA-302-PR	Electrical, General	☐	S3NA-502-PR	Benzene
☒	S3NA-303-PR	Excavation and Trenching	☐	S3NA-503-PR	Blood borne Pathogen Program
☐	S3NA-304-PR	Fall Protection	☐	S3NA-504-PR	Cadmium
☒	S3NA-305-PR	Hand and Power Tools	☒	S3NA-505-PR	Cold Stress Prevention
☐	S3NA-306-PR	Highway and Road Work	☐	S3NA-506-PR	Compressed Gases
☒	S3NA-307-PR	Housekeeping, Worksite	☒	S3NA-507-PR	Hazardous Materials Communication / WHMIS
☒	S3NA-308-PR	Manual Lifting, Field	☒	S3NA-508-PR	Hazardous Materials Handling and Shipping
☒	S3NA-309-PR	Mobile or Heavy Equipment	☒	S3NA-509-PR	Hazardous Waste Operations and Emergency Response Activities
☐	S3NA-310-PR	Rigging, Hoisting, Cranes and Lifting Devises	☒	S3NA-510-PR	Hearing Conservation Program
☐	S3NA-311-PR	Scaffolding	☒	S3NA-511-PR	Heat Stress Prevention
☐	S3NA-312-PR	Ladders and Stairways	☐	S3NA-512-PR	Laboratory Safety
☒	S3NA-313-PR	Wildlife, Plants and Insects	☐	S3NA-513-PR	Lead
☒	S3NA-314-PR	Working Alone & Remote Travel	☐	S3NA-514-PR	Munitions and Explosives of Concern / Unexploded Ordnance (MEC-UXO)
☐	S3NA-315-PR	Water, Working Around	☐	S3NA-515-PR	Nanotechnology
			☐	S3NA-516-PR	Radiation Safety Programs
S3NA 400 Series Field (Uncommon)			☐	S3NA-517-PR	Radiation, Non-Ionizing
☐	S3NA-401-PR	Aircraft Charters	☐	S3NA-518-PR	Radiation, Gauge Source program
☐	S3NA-402-PR	All Terrain Vehicles (ATVs)	☐	S3NA-519-PR	Respiratory Protection Program
☐	S3NA-403-PR	Avalanches	☒	S3NA-520-PR	Spill Response, Incidental
☐	S4NA(US)-404-PR	Commercial Motor Vehicles			
☒	S3NA-405-PR	Drilling and Boring			
☒	S3NA-406-PR	Electrical Lines, Overhead			
☐	S3NA-407-PR	Electro-fishing			
☐	S3NA-408-PR	Elevated Work Platforms and Aerial Lifts			
☐	S3NA-409-PR	Forklifts (operation of)			
☐	S3NA-410-PR	Hazardous Energy Control			
☐	S3NA-411-PR	Machine Guarding			
☐	S3NA-412-PR	Powder-Actuated Tools			
☐	S4NA(US)-413-PR1	Process Safety Management			
☐	S4NA(US)-414-PR	Railway Sites			
☐	S4NA(US)-415-PR	RCRA Regulated Facilities			
☐	S3NA-416-PR	Tunnel and Underground Work			
☒	S3NA-417-PR	Utilities, Underground			
☐	S3NA-418-PR	Welding, Cutting and Other Hot Work			
☐	S3NA-419-PR	Water, Marine Operations, Boating			
☐	S3-NA420-PR	Water, Underwater Diving			

4.0 SH&E Requirements (Safety)

4.1 HAZWOPER Qualifications

Personnel performing work at the job site must be qualified as HAZWOPER workers (unless otherwise noted in specific THAs or by the SSO), and must meet the medical monitoring and training requirements specified in the AECOM's North America SH&E Standard Operating Procedures.

If site monitoring procedures indicate that a possible exposure has occurred above the OSHA permissible exposure limit (PEL), employees may be required to receive supplemental medical testing to document any symptoms that may be specific to the particular materials present.

4.2 Site-Specific Safety Training

All AECOM personnel performing activities at the site will be trained in accordance with *S3NA-003-PR SH&E Training*. All personnel are required to remain current in all of their required training and evaluate their need for additional training when there is a change in work. In addition to the general health and safety training programs, personnel will be required to complete any supplemental task specific training developed for the tasks to be performed. Administration and compliance with the requirements for additional task-specific training will be the responsibility of the project or lead manager. Any additional required training that is completed will be documented and tracked in the project files.

4.2.1 Competent Person Training Requirements

In order to complete the planned scope of work, an (OSHA conformance) competent person must be designated to perform the required daily on site inspections of operations and/or equipment. The competent person may be an AECOM (if responsible for supervising that activity) or the subcontractor's employee. Designated competent person(s) for this project are shown in Table 4-2:

Table 4.2.1: Task-Specific Competent Persons

Employee Name	Organization	Area of Competency
TBD	Subcontractor Employee	Soil Excavation
TBD	Subcontractor Employee	Heavy Equipment Operator

Note: The training requirements for competent persons are specified in the indicated SOPs and/or *S3NA-202-PR Competent Person Designation*. By identifying an employee as a "competent person", that person has now been authorized to take prompt corrective measures to eliminate hazards.

4.3 Tailgate Meetings

Prior to the commencement of daily project activities, a tailgate meeting will be conducted by the SSO to review the specific requirements of this HASP, applicable THA. Attendance at the daily tailgate meeting is mandatory for all employees at the site covered by this HASP and must be documented on the attendance form. All safety training documentation is to be maintained in the project file by the SSO.

4.4 Hazard Communication

Hazardous materials that may be encountered as existing on-site environmental or physical/health contaminants during the work activities are addressed in this HASP and their properties, hazards and associated required controls will be communicated to all affected staff and subcontractors.

In addition, any employee or organization (contractor or subcontractor) intending to bring any hazardous material onto this AECOM-controlled work site must first provide a copy of the item's Material Safety Data Sheet (MSDS) to the SSO for review and filing (the SSO will maintain copies of all MSDS on site). MSDS may not be available for locally-obtained products, in which case some alternate form of product hazard documentation will be acceptable in accordance with the requirements of *S3NA-507-PR Hazardous Materials Communication/WHMIS*.

All personnel shall be briefed on the hazards of any chemical product they use, and shall be aware of and have access to all MSDS.

All containers on site shall be properly labeled to indicate their contents. Labeling on any containers not intended for single-day, individual use shall contain additional information indicating potential health and safety hazards (flammability, reactivity, etc.).

Attachment B provides copies of MSDS for those items planned to be brought on site at the time this HASP is prepared. This information will be updated as required during site operations.

4.5 Confined Space Entry

Confined space entry is not anticipated for activities performed at this site.

4.6 Hazardous, Solid, or Municipal Waste

If hazardous, solid, and/or municipal wastes are generated during any phase of the project, the waste shall be accumulated, labeled, and disposed of in accordance with applicable Federal, State, Provincial, Territorial and/or local regulations. Consult the Regional SH&E Manager for further guidance.

4.7 General Safety Rules

All site personnel shall conduct themselves in a safe manner and maintain a working environment that is free of additional hazards, in adherence to *S3NA-001-PR Safe Work Standards and Rules* and *S3NA-103-PR General Housekeeping*.

4.7.1 Housekeeping

During site activities, work areas will be continuously policed for identification of excess trash and unnecessary debris. Excess debris and trash will be collected and stored in an appropriate container (e.g., plastic trash bags, garbage can, roll-off bin) prior to disposal. At no time will debris or trash be intermingled with waste PPE or contaminated materials.

4.7.2 Smoking, Eating, or Drinking

Smoking, eating and drinking will not be permitted inside any controlled work area at any time. Field workers will first wash hands and face immediately after leaving controlled work areas (and always prior to eating or drinking). Consumption of alcoholic beverages is prohibited at any AECOM site. Smoking, eating or drinking must be in an approved area.

4.7.3 Personal Hygiene

The following personal hygiene requirements will be observed:

<u>Water Supply</u>: A water supply meeting the following requirements will be utilized:

> *Potable Water* - An adequate supply of potable water will be available for field personnel consumption. Potable water can be provided in the form of water bottles, canteens, water coolers, or drinking fountains. Where drinking fountains are not available, individual-use cups will be provided as well as adequate disposal containers. Potable water containers will be properly identified in order to distinguish them from non-potable water sources.
>
> *Non-Potable Water* - Non-potable water may be used for hand washing and cleaning activities. Non-potable water will not be used for drinking purposes. All containers of non-potable water will be marked with a label stating:

Non-Potable Water
Not Intended for Drinking Water Consumption

<u>Toilet Facilities</u>: A minimum of one toilet will be provided for every 20 personnel on site, with separate toilets maintained for each sex except where there are less than 5 total personnel on site. For mobile crews where work activities and locations permit transportation to nearby toilet facilities on-site facilities are not required.

<u>Washing Facilities</u>: Employees will be provided washing facilities (e.g., buckets with water and Alconox) at each work location. The use of water and hand soap (or similar substance) will be required by all employees following exit from the Exclusion Zone, prior to breaks, and at the end of daily work activities.

4.7.4 Buddy System

All field personnel will use the buddy system when working within any controlled work area. Personnel belonging to another organization on site can serve as "buddies" for AECOM personnel. Under no circumstances will any employee be present alone in a controlled work area. For areas not in controlled work areas, the procedures outlined in *S3NA-314-PR Working Alone Remote Travel* will be followed at all times.

4.8 Stop Work Authority

All employees have the right and duty to stop work when conditions are unsafe and to assist in correcting these conditions as outlined in *S3NA-002-PR Stop Work Authority.* Whenever the SSO determines that workplace conditions present an uncontrolled risk of injury or illness to employees, immediate resolution with the appropriate supervisor shall be sought.

Should the supervisor be unable or unwilling to correct the unsafe conditions, the SSO is authorized and required to stop work, which shall be immediately binding on all affected AECOM employees and subcontractors.

Upon issuing the stop work order, the SSO shall implement corrective actions so that operations may be safely resumed. Resumption of safe operations is the primary objective; however, operations shall not resume until the Safety Professional has concurred that workplace conditions meet acceptable safety standards.

4.9 **Client Specific Safety Requirements**

The client has specified no additional health and safety requirements.

5.0 Exposure Monitoring Procedures (Health)

5.1 Contaminant Exposure Hazards

The following is a discussion of the hazards presented to worker personnel during this project from on-site chemical hazards known, suspected or anticipated to be present on site.

Exposure symptoms and applicable first aid information for each suspected site contaminant identified in the Scope of Work are located in the following subsections.

5.1.1 BTEX

The aromatic compounds of BTEX are generally found together as significant components of petroleum fuels (e.g., diesel fuel). Due to their high vapor pressure and the range and severity of their health effects, they are considered to present the greatest hazard during remedial and site investigation operations. Mitigation measures include the use of chemically-protective gloves and clothing, and air-purifying respirators equipped with organic vapor cartridges.

Benzene. Benzene is a known human carcinogen. Prolonged skin contact with benzene or excessive inhalation of its vapor may cause headache, weakness, loss of appetite, and lassitude. Continued exposure can cause collapse, bronchitis, and pneumonia. The most important health hazards are cancer (leukemia), bone marrow effects, and injuries to the blood-forming tissue from chronic low-level exposure. The OSHA PEL is 1 ppm, with an action level of 0.5 ppm and a short-term exposure limit of 5.0 ppm. The ACGIH exposure guideline is 0.5 ppm.

Toluene. Exposure to vapors of toluene may cause irritation of the eyes, nose, upper respiratory tract, and skin. Exposure to 200 ppm for 8 hours causes mild fatigue, weakness, confusion, tearing, and a sensation of prickling, tingling, or creeping on the skin that has no objective cause. Exposure to higher concentrations may cause headache, nausea, dizziness, dilated pupils, and euphoria, and in severe cases may cause unconsciousness and death. The liquid is irritating to the eyes and the skin. Contact with the eyes may cause transient corneal damage, conjunctival irritation, and burns if not promptly removed. Repeated or prolonged contact with the skin may cause drying and cracking. Toluene may be absorbed through the skin in toxic amounts. Ingestion causes irritation of the gastrointestinal tract and may cause effects resembling those from inhalation of the vapor. Chronic overexposure to toluene may cause irreversible liver and kidney injury. The OSHA PEL is 200 ppm; the ACGIH TLV is 50 ppm.

Ethylbenzene. Ethylbenzene vapors are severely irritating to the eyes and the mucous membranes of the respiratory system. Sustained inhalation of excessive levels can cause depression of the central nervous system (CNS) characterized by dizziness, headache, narcosis, and coma. Skin contact with liquid ethylbenzene causes irritation; dermatitis and defatting can also develop. The acute oral toxicity of ethylbenzene is low; however, ingestion of it poses a serious aspiration hazard. Aspirating even a small amount into the lungs can result in extensive edema (lungs filled with fluid) and hemorrhaging of the lung tissue. No systemic effects are suspected at the levels that produce pronounced, disagreeable skin and eye irritation. The established PEL is set well below this intolerable level. The OSHA PEL and ACGIH TLV are all 100 ppm.

Xylene. Liquid xylene is a skin irritant and causes itching, dryness, and defatting; prolonged contact may cause blistering. Inhaling xylenes can depress the CNS, and ingesting it can result in gastrointestinal disturbance and possibly hematemesis (vomiting blood). Effects on the eyes, kidneys, liver, lungs, and the CNS are also reported. Both the OSHA PEL and ACGIH TLV are 100 ppm.

5.1.2 PAHs

Polynuclear aromatic hydrocarbons (PAHs) are produced during combustion events due to inadequate oxidation of fuel. PAHs in the pure state are yellowish crystalline solids. They are found in coal tar and in products of incomplete combustion. These chemicals have varying degrees of potency for causing cancer, with benzo(a)pyrene being among the most potent. PAHs are evaluated collectively as coal tar pitch volatiles. Coal tar pitch volatiles may cause photosensitization and a rash where sunlight strikes the skin. Exposure may also cause cancer of lungs, skin, bladder, or kidneys. Benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3,c,d)pyrene have been identified as carcinogenic.

This information on PAH compounds is presented for site contaminant awareness. While the potential for site personnel sustaining significant inhalation exposures to volatilized PAH compounds during this project's site activities is minimal, there is the potential for inhalation of PAH-contaminated dust, and handling of contaminated soil presents skin exposure hazards. Use of dust-suppression techniques (as appropriate) and the proper use of air-purifying respirators equipped with P100 cartridges and chemically-protective gloves will adequately protect personnel.

5.1.3 Metals (Arsenic and Lead)

Lead may are present in the soil at Hillside Elementary School. As a group, heavy metals are toxic to a number of organs and organ systems in the body, including the liver, kidneys, blood-forming organs (primarily located in the bones), and the CNS (especially lead). Acute exposure to metals can produce symptoms, such as stomach distress and vomiting, mental confusion and sluggishness, heart palpitations, breathing difficulties, and renal (kidney) failure. Chronic exposure can be characterized by CNS degradation and deterioration of liver and kidney function. The Cal/OSHA PEL and ACGIH TLV for the metals of concern are listed below:

Metal	OSHA PEL (mg/m^3)	ACGIH TLV (mg/m^3)
Lead	0.05	0.05

mg/m^3 = milligram per cubic meter

The expected concentrations of lead, although of environmental concern, are considered only low to moderate, presenting minimal occupational safety or health hazards. The primary route of exposure to lead during this project is contact with contaminated soils, which can lead to ingestion exposure through contamination of food. Protection against ingestion can be accomplished using a combination of protective clothing and decontamination procedures.

5.1.4 Cyanide

As a group, the heavy metals (including lead, arsenic, cyanide) are toxic to a number of organs and organ systems in the body, including the liver, kidneys, blood-forming organs (primarily located in the bones), and the CNS (especially lead). Acute exposure to metals can produce such symptoms as stomach distress and vomiting, mental confusion and sluggishness, heart palpitations, breathing difficulties, and renal (kidney) failure. Chronic exposures can be characterized by deterioration in function of the liver and kidneys, CNS degradation, and abnormal changes in blood cell counts (especially white blood cells). Exposure to chromium may also lead to formation of lung and gastric cancers.

The primary route of exposure to heavy metals of concern during this project is contact with contaminated soil and water, which can lead to entry through open wounds or contamination and ingestion of food. Preventing this route of exposure necessitates the use of dust control measures, administrative controls (e.g., no consumption of food/beverages in the work area or smoking/chewing tobacco), chemically-protective gloves, and decontamination procedures.

5.2 Route of Entry Assessment of Exposure Hazards

Inhalation: Exposure via inhalation is moderate to high do to excavation of impacted soils. Continuous air monitoring will be conducted in workers' breathing zone and perimeter. Dust suppression must be in place as engineering control.

Skin Contact: Skin contact is low to moderate risk due to workers wearing proper PPE (Modified D) during excavation activities. Ensuring gloves are worn during contact with samples and soil.

Ingestion: Protection against exposure via ingestion can be accomplished by performance of proper decontamination procedures when exiting contaminated work areas.

Monitoring procedures will be employed during site characterization activities to assess employee exposure to chemical and physical hazards. Monitoring will consist primarily of onsite determination of various parameters (e.g., airborne contaminant concentrations and heat stress effects), but may be supplemented by more sophisticated monitoring techniques, if necessary.

5.3 Real-Time Exposure Measurement

Monitoring shall be performed within the work area on site in order to detect the presence and relative levels of toxic substances. The data collected throughout monitoring shall be used to determine the appropriate levels of PPE. Monitoring shall be conducted as specified in each THA as work is performed.

Table 5-1 specifies the real-time monitoring equipment, which will be used for this project.

Table 5-1: Monitoring Parameters and Equipment

INSTRUMENT	MANUFACTURER/MODEL*	SUBSTANCES DETECTED
Photo Ionization Detector (PID)	RAE Systems mini-RAE Photovac Microtip HNu Model Hnu (min. 10.2 eV bulb)	Petroleum hydrocarbons Organic Solvents

INSTRUMENT	MANUFACTURER/MODEL*	SUBSTANCES DETECTED
Particulate Monitor	MIE Model PDM-3 mini-RAM	Aerosols, mist, dust, and fumes
Colorimetric Detector Tubes	Sensidyne Draeger	Benzene 0.5–10 ppm

*Or similar unit, as approved by the SH&E Professional

5.4 Health and Safety Action Levels

An action level is a point at which increased protection is required due to the concentration of contaminants in the work area or other environmental conditions. The concentration level (above background level) and the ability of the PPE to protect against that specific contaminant determine each action level. The action levels are based on concentrations in the breathing zone.

If ambient levels are measured which exceed the action levels in areas accessible to unprotected personnel, necessary control measures (barricades, warning signs, and mitigative actions to limit, etc.) must be implemented prior to commencing activities at the specific work area.

Personnel should also be able to upgrade or downgrade their level of protection with the concurrence of SSO or the Safety Professional.

Reasons to upgrade:

- Known or suspected presence of dermal hazards.
- Occurrence or likely occurrence of gas, vapor, or dust emission.
- Change in work task that will increase the exposure or potential exposure to hazardous materials.

Reasons to downgrade:

- New information indicating that the situation is less hazardous than was originally suspected.
- Change in site conditions that decrease the potential hazard.
- Change in work task that will reduce exposure to hazardous materials.

5.4.1 Monitoring Procedures

PARAMETER	LOCATION AND INTERVAL	RESPONSE LEVEL (Meter units/ppm above background)	RESPONSE
Hydrocarbons (Total by PID, see "RESPONSE" for chemical-specific monitoring using detector tubes when meter units are 1-5)	Prior to initial entry in to impacted areas and then at least every 30 minutes afterwards in the worker's breathing zone or in the immediate work area.	< 1	Continue Level D or Modified Level D work and continue monitoring.
		≥ 1 (If no detector tubes drawn)	If no detector tubes are drawn, upgrade to Level C PPE (minimum GMA/P100 cartridges or equivalent chemical cartridge combined with P100). Monitor for specific chemical(s) listed below and continue monitoring.
		PID ≥ 1 - 5 and; benzene < 0.5 ppm	Periodically monitor with chemical-specific detector tubes. Contact the SSO or HSM, implement mitigation measures, and continue work in Level D. **See chemical-specific monitoring information below** and continue monitoring.
		≥ 5 - < 10	Upgrade to Level C PPE (minimum GMA/P100 cartridges or equivalent chemical cartridge combined with P100). Continue environmental monitoring.
		≥ 10	Cease work, exit the area, contact the SSO or HSM and upgrade to Level B.
Dust, Mist, Aerosols (Total by Mini-Ram)*	At least every 30 minutes in the worker's breathing zone during intrusive activities involving impacted materials. In addition, site perimeter monitoring may be initiated by the SSO based on elevated air monitoring results.	Initial excavation or disturbance of unknown materials	Level C ensemble as listed in this HASP and per SSO and SH&E Manager.
		< 0.5 mg/m^3 (Sustained for more than 5 minutes)	Continue Level D work and continue monitoring.
		≥ 0.5 mg/m^3 (Sustained for more than 5 minutes)	Upgrade to Level C PPE. Contact the RM and SSO, implement mitigation measures, and continue Level C (minimum GMA/P100 cartridges or equivalent chemical cartridge combined with P100) and continue monitoring.
		≥ 1 mg/m^3 (Sustained for more than 5 minutes)	Temporarily cease work operations, contact the RM and SH&E Manager to discuss improving site mitigation measures. Possible upgrade to Level B for exclusion zone workers.

5.4.1.1 Monitoring Equipment Calibration

All instruments used will be calibrated at the beginning and end of each work shift, in accordance with the manufacturer's recommendations. If the owner's manual is not available, the personnel operating the equipment will contact the applicable office representative, rental agency or manufacturer for technical guidance for proper calibration. If equipment cannot be pre-calibrated to specifications, site operations requiring monitoring for worker exposure or off-site migration of contaminants will be postponed or temporarily ceased until this requirement is completed.

5.4.1.2 Personal Sampling

Should site activities warrant performing personal sampling (breathing zone) to better assess chemical exposures experienced by AECOM employees, the SSO, under the direction of a Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP) will be responsible for specifying the monitoring required. Within five working days after the receipt of monitoring results, the CIH or CSP will notify each employee, in writing, of the results that represent that employee's exposure. Copies of air sampling results will be maintained in the SSO project files.

If the site activities warrant, the subcontractor will ensure its employees' exposures are quantified via the use of appropriate sampling techniques. The subcontractor shall notify the employees sampled in accordance with health and safety regulations, and provide the results to the SSO for use in determining the potential for other employees' exposure.

5.5 Heat and Cold Stress

Heat and cold stress may vary based upon work activities, PPE/clothing selection, geographical locations, and weather conditions. To reduce the potential of developing heat/cold stress, be aware of the signs and symptoms of heat/cold stress and watch fellow employees for signs of heat/cold stress.

Heat stress can be a significant field site hazard, particularly for non-acclimated personnel operating in a hot, humid setting. Site personnel will be instructed in the identification of a heat stress victim, the first-aid treatment procedures for the victim and the prevention of heat stress casualties. Work-rest cycles will be determined and the appropriate measures taken to prevent heat stress as outlined in *S3NA-511-PR Heat Stress Prevention Program*.

5.5.1 Responding to Heat-Related Illness

The guidance below will be used in identifying and treating heat-related illness.

Table 5.5.1: Identification and Treatment of Heat-Related Illness

Type of Heat-Related Illness	Description	First Aid
Mild Heat Strain	The mildest form of heat-related illness. Victims exhibit irritability, lethargy, and significant sweating. The victim may complain of headache or nausea. This is the initial stage of overheating, and prompt action at this point may prevent more severe heat-related illness from occurring.	• Provide the victim with a work break during which he/she may relax, remove any excess protective clothing, and drink cool fluids. • If an air-conditioned spot is available, this is an ideal break location. • Once the victim shows improvement, he/she may resume working; however, the work pace should be moderated to prevent recurrence of the symptoms.
Heat Exhaustion	Usually begins with muscular weakness and cramping, dizziness, staggering gait, and nausea. The victim will have pale, clammy moist skin and may perspire profusely. The pulse is weak and fast and the victim may faint unless they lie down. The bowels may move involuntarily.	• Immediately remove the victim from the work area to a shady or cool area with good air circulation (*avoid drafts or sudden chilling*). • Remove all protective outerwear. • Call a physician. • Treat the victim for shock. (*Make the victim lie down, raise his or her feet 6–12 inches, and keep him/her cool by loosening all clothing*). • If the victim is conscious, it may be helpful to give him/ her sips of water. • Transport victim to a medical facility ASAP.
Heat Stroke	The most serious of heat illness, heat stroke represents the collapse of the body's cooling mechanisms. As a result, body temperature may rise to 104 degrees Fahrenheit or higher. As the victim progresses toward heat stroke, symptoms such as headache, dizziness, nausea can be noted, and the skin is observed to be dry, red, and hot. Sudden collapse and loss of consciousness follows quickly and death is imminent if exposure continues. Heat stroke can occur suddenly.	• Immediately evacuate the victim to a cool/shady area. • Remove all protective outerwear and as much personal clothing as decency permits. • Lay the victim on his/her back w/the feet slightly elevated. • Apply cold wet towels or ice bags to the head, armpits, and thighs. • Sponge off the bare skin with cool water. • The main objective is to cool without chilling the victim. • Give no stimulants or hot drinks. • Since heat stroke is a severe medical condition requiring professional medical attention, emergency medical help should be summoned immediately to provide onsite treatment of the victim and proper transport to a medical facility.

6.0 Environmental Program (Environment)

6.1 Environmental Compliance and Management

This project and the individual tasks will comply with all federal, state, provincial, and local environmental requirements.

6.1.1 Air Emissions

A discussion of air emissions is provided in the Ambient Air Monitoring Plan (AAMP, Appendix E of the RAWP).

6.1.2 Hazardous Waste Management

If hazardous, solid and/or municipal wastes are generated during any phase of the project, the waste shall be accumulated, labeled, and disposed of in accordance with applicable Federal, State, and/or local regulations.

6.1.3 Storm Water Pollution Prevention

Any stockpiles of excavated affected soil will be covered with plastic to prevent storm water pollution.

6.1.4 Wetlands Protection

There are no wetlands on or adjacent to the site.

6.1.5 Critical Habitat Protection

The Site is not located within a designated park, forest, wildlife refuge, or other protected area.

7.0 Personal Protective Equipment

7.1 Personal Protective Equipment

The purpose of personal protective equipment (PPE) is to provide a barrier, which will shield or isolate individuals from the chemical and/or physical hazards that may be encountered during work activities. *S3NA-208-PR Personal Protective Equipment Program* lists the general requirements for selection and usage of PPE. **Table 7-1** lists the minimum PPE required during site operations and additional PPE that may be necessary. The specific PPE requirements for each work task are specified in the individual THAs.

By signing this HASP the employee agrees to having been trained in the use, limitations, care and maintenance of the protective equipment to be used by the employee at this project. If training has not been provided, request some of the PM/SSO for the proper training before signing.

Table 7-1: Personal Protective Equipment

TYPE	MATERIAL	ADDITIONAL INFORMATION
Minimum PPE		
Safety Vest	ANSI Type II high-visibility	Must have reflective tape/be visible from all sides.
Boots	Leather	ANSI approved safety toe.
Safety Glasses		ANSI Approved; ≥98% UV protection.
Hard Hat		ANSI Approved; recommended wide-brim.
Work Uniform		No shorts/cutoff jeans or sleeveless shirts.
Additional PPE		
Hearing Protection	Ear plugs and/ or muffs	In hazardous noise areas.
Leather Gloves		If working with sharp objects or powered equipment.
Protective Chemical Gloves	Nitrile	
Protective Chemical Coveralls	Tyvek	
Protective Chemical Boots		
Level C Respiratory Protection	MSA (Full Face or equivalent) equipped with GMA/P100	
Face Shield		When splash hazard exists. Safety glasses or goggles must be worn concurrently.
Sunscreen	SPF 30 or higher	
Cooling Vest		
Cold Weather Gear	Hard hat liner, hand warmers, insulated gloves	

7.2 PPE Doffing and Donning (UTILIZATION) Information

The following information is to provide field personnel with helpful hints that, when applied, make donning and doffing of PPE a more safe and manageable task:

- Never cut disposable booties from your feet with basic utility knives. This has resulted in workers cutting through the booty and the underlying sturdy leather work boot, resulting in significant cuts to the legs/ankles. Recommend using a pair of scissors or a package/letter opener (cut above and parallel with the work boot) to start a cut in the edge of the booty, then proceed by manually tearing the material down to the sole of the booty for easy removal.
- When applying duct tape to PPE interfaces (wrist, lower leg, around respirator, etc.) and zippers, leave approximately one inch at the end of the tape to fold over onto itself. This will make it much easier to remove

the tape by providing a small handle to grab while still wearing gloves. Without this fold, trying to pull up the tape end with multiple gloves on may be difficult and result in premature tearing of the PPE.

- Have a “buddy” check your ensemble to ensure proper donning before entering controlled work areas. Without mirrors, the most obvious discrepancies can go unnoticed and may result in a potential exposure situation.
- Never perform personal decontamination with a pressure washer.

7.3 Decontamination

7.3.1 General Requirements

All possible and necessary steps shall be taken to reduce or minimize contact with chemicals and contaminated/impacted materials while performing field activities (e.g., avoid sitting or leaning on, walking through, dragging equipment through or over, tracking, or splashing potential or known contaminated/impacted materials, etc).

All personal decontamination activities shall be performed with an attendant (buddy) to provide assistance to personnel that are performing decontamination activities. Depending on specific site hazards, attendants may be required to wear a level of protection that is equal to the required level in the Exclusion Zone (EZ).

All persons and equipment entering the EZ shall be considered contaminated, and thus, must be properly decontaminated prior to entering the SZ.

Decontamination procedures may vary based on site conditions and nature of the contaminant(s). If chemicals or decontamination solutions are used, care should be taken to minimize reactions between the solutions and contaminated materials. In addition, personnel must assess the potential exposures created by the decontamination chemical(s) or solutions. The applicable Material Safety Data Sheet (MSDS) must be reviewed, implemented, and filed by personnel contacting the chemicals/solutions.

All contaminated PPE and decontamination materials shall be contained, stored and disposed of in accordance with site-specific requirements determined by site management.

7.3.2 Decontamination Equipment

The equipment required to perform decontamination may vary based on site-specific conditions and the nature of the contaminant(s). The following equipment is commonly used for decontamination purposes:

- Soft-bristle scrub brushes or long-handled brushes to remove contaminants;
- Hoses, buckets of water or garden sprayers for rinsing;
- Large plastic/galvanized wash tubs or children's wading pools for washing and rinsing solutions;
- Large plastic garbage cans or similar containers lined with plastic bags for the storage of contaminated clothing and equipment;
- Metal or plastic cans or drums for the temporary storage of contaminated liquids; and
- Paper or cloth towels for drying protective clothing and equipment.

7.3.3 Personal/Equipment Decontamination

All equipment leaving the EZ shall be considered contaminated and must be properly decontaminated to minimize the potential for exposure and off-site migration of impacted materials. Such equipment may include, but is not limited to: sampling tools, heavy equipment, vehicles, PPE, support devices (e.g., hoses, cylinders, etc.), and various handheld tools.

All employees performing equipment decontamination shall wear the appropriate PPE to protect against exposure to contaminated materials. The level of PPE may be equivalent to the level of PPE required in the EZ. Other PPE may include splash protection, such as face-shields and splash suits, and knee protectors. Following equipment decontamination, employees may be required to follow the proper personal decontamination procedures above.

For larger equipment, a high-pressure washer may need to be used. Some contaminants require the use of a detergent or chemical solution and scrub brushes to ensure proper decontamination.

For smaller equipment, use the following steps for decontamination:

- Remove majority of visible gross contamination in EZ.

- Wash equipment in decontamination solution with a scrub brush and/or power wash heavy equipment.
- Rinse equipment.
- Visually inspect for remaining contamination.
- Follow appropriate personal decontamination steps outlined above.

All decontaminated equipment shall be visually inspected for contamination prior to leaving the Contaminant Reduction Zone (CRZ). Signs of visible contamination may include an oily sheen, residue or contaminated soils left on the equipment. All equipment with visible signs of contamination shall be discarded or re-decontaminated until clean. Depending on the nature of the contaminant, equipment may have to be analyzed using a wipe method or other means.

8.0 Project Health and Safety Organization

8.1 **Project Manager** [Jeffrey Nelson]

The Project Manager (PM) has overall management authority and responsibility for all site operations, including safety. The PM will provide the site supervisor with work plans, staff, and budgetary resources, which are appropriate to meet the safety needs of the project operations.

8.2 **Site Supervisor**

The site supervisor has the overall responsibility and authority to direct work operations at the job site according to the provided work plans. The PM may act as the site supervisor while on site.

8.2.1 Responsibilities

The site supervisor is responsible to:

- Discuss deviations from the work plan with the SSO and PM.
- Discuss safety issues with the PM, SSO, and field personnel.
- Assist the SSO with the development and implementation of corrective actions for site safety deficiencies.
- Assist the SSO with the implementation of this HASP and ensuring compliance.
- Assist the SSO with inspections of the site for compliance with this HASP and applicable SOPs.

8.2.2 Authority

The site supervisor has authority to:

- Verify that all operations are in compliance with the requirements of this HASP, and halt any activity that poses a potential hazard to personnel, property, or the environment.
- Temporarily suspend individuals from field activities for infractions against the HASP pending consideration by the SSO, the Safety Professional, and the PM.

8.2.3 Qualifications

In addition to being Hazardous Waste Operations and Emergency Response (HAZWOPER)-qualified (see Section 4.1), the Site Supervisor is required to have completed the 8-hour HAZWOPER Supervisor Training Course in accordance with 29 CFR 1910.120 (e)(4).

8.3 **Site Safety Officer**

8.3.1 Responsibilities

The SSO is responsible to:

- Update the site-specific HASP to reflect changes in site conditions or the scope of work. HASP updates must be reviewed and approved by the Safety Professional.
- Be aware of changes in AECOM Safety Policy.
- Monitor the lost time incidence rate for this project and work toward improving it.
- Inspect the site for compliance with this HASP and the SOPs using the appropriate audit inspection checklist provided by an AECOM Safety Professional.
- Work with the site supervisor and PM to develop and implement corrective action plans to correct deficiencies discovered during site inspections. Deficiencies will be discussed with project management to determine appropriate corrective action(s).
- Contact the Safety Professional for technical advice regarding safety issues.

- Provide a means for employees to communicate safety issues to management in a discreet manner (i.e., suggestion box, etc.).
- Determine emergency evacuation routes, establishing and posting local emergency telephone numbers, and arranging emergency transportation.
- Check that all site personnel and visitors have received the proper training and medical clearance prior to entering the site.
- Establish any necessary controlled work areas (as designated in this HASP or other safety documentation).
- Present tailgate safety meetings and maintain attendance logs and records.
- Discuss potential health and safety hazards with the Site Supervisor, the Safety Professional, and the PM.
- Select an alternate SSO by name and inform him/her of their duties, in the event that the SSO must leave or is absent from the site.

8.3.2 Authority

The SSO has authority to:

- Verify that all operations are in compliance with the requirements of this HASP.
- Issue a “Stop Work Order” under the conditions set forth in this HASP.
- Temporarily suspend individuals from field activities for infractions against the HASP pending consideration by the Safety Professional and the PM.

8.3.3 Qualifications

In addition to being HAZWOPER-qualified, the SSO is required to have completed the 8-hour HAZWOPER Supervisor Training Course in accordance with 29 CFR 1910.120 (e)(4).

8.4 Employees

8.4.1 Employee Responsibilities

Responsibilities of employees associated with this project include, but are not limited to:

- Understanding and abiding by the policies and procedures specified in the HASP and other applicable safety policies, and clarifying those areas where understanding is incomplete.
- Providing feedback to health and safety management relating to omissions and modifications in the HASP or other safety policies.
- Notifying the SSO, in writing, of unsafe conditions and acts.

8.4.2 Employee Authority

The health and safety authority of each employee assigned to the site includes the following:

- The right to refuse to work and/or stop work authority when the employee feels that the work is unsafe (including subcontractors or team contractors), or where specified safety precautions are not adequate or fully understood.
- The right to refuse to work on any site or operation where the safety procedures specified in this HASP or other safety policies are not being followed.
- The right to contact the SSO or the Safety Professional at any time to discuss potential concerns.
- The right and duty to stop work when conditions are unsafe, and to assist in correcting these conditions.

8.5 **Safety Professional** [Brett Hodgson]

The Safety Professional is the member of the AECOM Safety, Health and Environmental Department assigned to provide guidance and technical support for the project. Duties include the following:

- Approving this HASP and any required changes.
- Approving the designated Site Safety Officer (SSO).
- Reviewing all personal exposure monitoring results.
- Investigating any reported unsafe acts or conditions.

8.6 **Subcontractors**

The requirements for subcontractor selection and subcontractor safety responsibilities are outlined in *S3NA-213-PR Subcontractors*. Each AECOM subcontractor is responsible for assigning specific work tasks to their employees. Each subcontractor's management will provide qualified employees and allocate sufficient time, materials, and equipment to safely complete assigned tasks. In particular, each subcontractor is responsible for equipping its personnel with any required personnel protective equipment (PPE and all required training.

AECOM considers each subcontractor to be an expert in all aspects of the work operations for which they are tasked to provide, and each subcontractor is responsible for compliance with the regulatory requirements that pertain to those services. Each subcontractor is expected to perform its operations in accordance with its own unique safety policies and procedures, in order to ensure that hazards associated with the performance of the work activities are properly controlled. Copies of any required safety documentation for a subcontractor's work activities will be provided to AECOM for review prior to the start of onsite activities, if required.

Hazards not listed in this HASP but known to any subcontractor, or known to be associated with a subcontractor's services, must be identified and addressed to the AECOM PM or the Site Supervisor prior to beginning work operations. The Site Supervisor or authorized representative has the authority to halt any subcontractor operations, and to remove any subcontractor or subcontractor employee from the site for failure to comply with established health and safety procedures or for operating in an unsafe manner.

8.7 **Visitors**

Authorized visitors (e.g., client representatives, regulators, AECOM management staff, etc.) requiring entry to any work location on the site will be briefed by the PM on the hazards present at that location. Visitors will be escorted at all times at the work location and will be responsible for compliance with their employer's health and safety policies. In addition, this HASP specifies the minimum acceptable qualifications, training and personal protective equipment which are required for entry to any controlled work area; visitors must comply with these requirements at all times.

8.7.1 Visitor Access

Visitors to any HAZWOPER controlled-work area must comply with the health and safety requirements of this HASP, and demonstrate an acceptable need for entry into the work area. All visitors desiring to enter any controlled work area must observe the following procedures:

- A written confirmation must be received by AECOM documenting that each of the visitors has received the proper training and medical monitoring required by this HASP. Verbal confirmation can be considered acceptable provided such confirmation is made by an officer or other authorized representative of the visitor's organization.
- Each visitor will be briefed on the hazards associated with the site activities being performed and acknowledge receipt of this briefing by signing the appropriate tailgate safety briefing form.
- All visitors must be escorted by an AECOM employee.

If the site visitor requires entry to any EZ, but does not comply with the above requirements, all work activities within the EZ must be suspended. Until these requirements have been met, entry will not be permitted.

Unauthorized visitors, and visitors not meeting the specified qualifications, will not be permitted within established controlled work areas.

9.0 Site Control

9.1 General

The purpose of site control is to minimize potential contamination of workers, protect the public from site hazards, and prevent vandalism. The degree of site control necessary depends on the site characteristics, site size, and the surrounding community.

Controlled work areas will be established at each work location, and if required, will be established directly prior to the work being conducted. Diagrams designating specific controlled work areas will be drawn on site maps, posted in the support vehicle or trailer and discussed during the daily safety meetings. If the site layout changes, the new areas and their potential hazards will be discussed immediately after the changes are made. General examples of zone layouts have been developed for drilling and earth moving activities [(e.g., excavating, trenching, etc.) and are attached to this section.

9.2 Controlled Work Areas

Each HAZWOPER controlled work area will consist of the following three zones:

- Exclusion Zone: Contaminated work area.
- Contamination Reduction Zone: Decontamination area.
- Support Zone: Uncontaminated or "clean area" where personnel should not be exposed to hazardous conditions.

Each zone will be periodically monitored in accordance with the air monitoring requirements established in this HASP. The Exclusion Zone and the Contamination Reduction Zone are considered work areas. The Support Zone is accessible to the public (e.g., vendors, inspectors).

9.2.1 Exclusion Zone

The Exclusion Zone is the area where primary activities occur, such as sampling, remediation operations, installation of wells, cleanup work, etc. This area must be clearly marked with hazard tape, barricades or cones, or enclosed by fences or ropes. Only personnel involved in work activities, and meeting the requirements specified in the applicable THA and this HASP will be allowed in an Exclusion Zone.

The extent of each area will be sufficient to ensure that personnel located at/beyond its boundaries will not be affected in any substantial way by hazards associated with sample collection activities.

All personnel should be alert to prevent unauthorized, accidental entrance into controlled-access areas (the EZ and CRZ). If such an entry should occur, the trespasser should be immediately escorted outside the area, or all HAZWOPER-related work must cease. All personnel, equipment, and supplies that enter controlled-access areas must be decontaminated or containerized as waste prior to leaving (through the CRZ only).

9.2.2 Contamination Reduction Zone

The Contamination Reduction Zone is the transition area between the contaminated area and the clean area. Decontamination is the main focus in this area. The decontamination of workers and equipment limits the physical transfer of hazardous substances into the clean area. This area must also be clearly marked with hazard tape and access limited to personnel involved in decontamination.

9.2.3 Support Zone

The Support Zone is an uncontaminated zone where administrative and other support functions, such as first aid, equipment supply, emergency information, etc., are located. The Support Zone shall have minimal potential for significant exposure to contaminants (i.e., background levels).

Employees will establish a Support Zone (if necessary) at the site before the commencement of site activities. The Support Zone would also serve as the entry point for controlling site access.

9.3 Site Access Documentation

If implemented by the PM, all personnel entering the site shall complete the “Site Entry/Exit Log” located at the site trailer or primary site support vehicle.

9.4 Site Security

9.4.1 Site security is necessary to:

- Prevent the exposure of unauthorized, unprotected people to site hazards.
- Avoid the increased hazards from vandals or persons seeking to abandon other wastes on the site.
- Prevent theft.
- Avoid interference with safe working procedures.

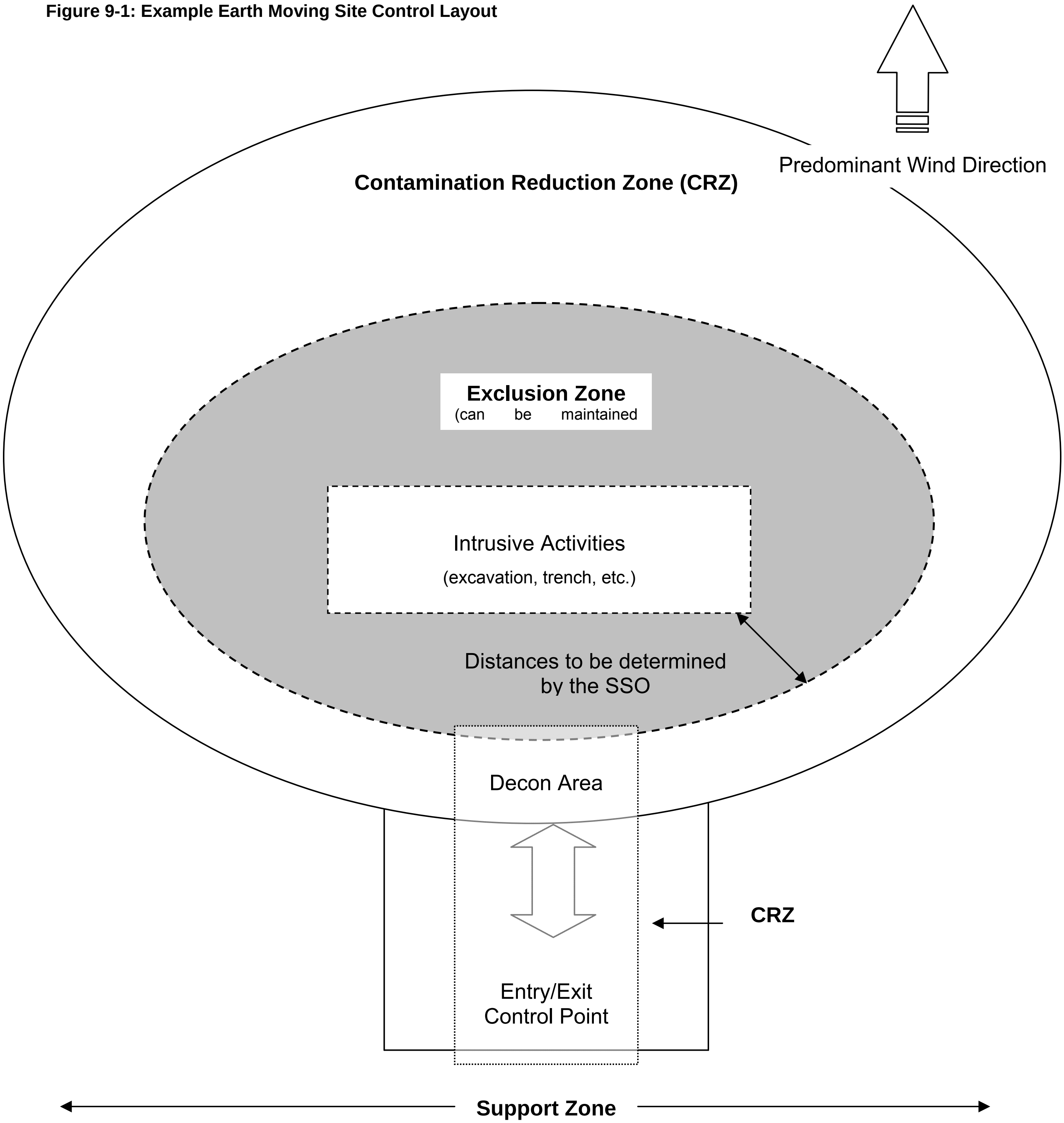
9.4.2 To maintain site security during working hours:

- Maintain security in the Support Zone and at access control points.
- Establish an identification system to identify authorized persons and limitations to their approved activities.
- Assign responsibility for enforcing authority for entry and exit requirements.
- When feasible, install fencing or other physical barrier around the site.
- If the site is not fenced, post signs around the perimeter and whenever possible, use guards to patrol the perimeter. Guards must be fully apprised of the hazards involved and trained in emergency procedures.
- Have the PM approve all visitors to the site. Make sure they have valid purpose for entering the site. Have trained site personnel accompany visitors at all times and provide them with the appropriate protective equipment.

9.4.3 To maintain site security during off-duty hours:

- If possible, assign trained, in-house technicians for site surveillance. They will be familiar with the site, the nature of the work, the site’s hazards, and respiratory protection techniques.
- If necessary, use security guards to patrol the site boundary. Such personnel may be less expensive than trained technicians, but will be more difficult to train in safety procedures and will be less confident in reacting to problems around hazardous substances.
- Enlist public enforcement agencies, such as the local police department, if the site presents a significant risk to local health and safety.
- Secure the equipment.

Figure 9-1: Example Earth Moving Site Control Layout



10.0 Emergency Response Planning

10.1 Emergency Action Plan

Although the potential for an emergency to occur is remote, an emergency action plan has been prepared for this project should such critical situations arise. The only significant type of onsite emergency that may occur is physical injury or illness to a member of the AECOM team. The Emergency Action Plan (EAP) will be reviewed by all personnel prior to the start of field activities. A test of the EAP will be performed within the first three (3) days of the project field operations. This test will be evaluated and documented in the project records.

10.1.1 Three major categories of emergencies could occur during site operations:

- Illnesses and physical injuries (including injury-causing chemical exposure)
- Catastrophic events (fire, explosion, earthquake, or chemical)
- Workplace Violence, Bomb Threat
- Safety equipment problems

10.1.2 Emergency Coordinator

The duties of the Emergency Coordinator (EC) include:

- Implement the EAP based on the identified emergency condition.
- Notify the appropriate project and SH&E Department personnel of the emergency (**Table 9-3**).
- Verify emergency evacuation routes and muster points are accessible.
- Conduct routine EAP drills and evaluate compliance with the EAP.

10.1.3 Site-Specific Emergency Procedures

Prior to the start of site operations, the EC will complete **Table 9-1** with any site-specific information regarding evacuations, muster points, communication, and other site-specific emergency procedures.

Table 10-1: Emergency Planning

Emergency	Evacuation Route	Muster Location
Chemical Spill	Upwind	
Fire/Explosion	Upwind	Maintain distance of 1,000 feet.
Tornado		
Lightning		Vehicle
Additional Information		
Communication Procedures	SSO will communicate with all personnel via direct contact, radio or cell phone.	
CPR/First Aid Trained Personnel	All AECOM field personnel are required to have up-to-date CPR/First Aid certification.	
Site-Specific Spill Response Procedures	N/A	

10.1.4 Spill Containment Procedure

Work activities may involve the use of hazardous materials (i.e. fuels, solvents) or work involving drums or other containers. Where these activities exist, a site-specific Spill Reporting Card will be developed. Procedures outlined below will be used to prevent or contain spills:

- All hazardous material will be stored in appropriate containers
- Tops/lids will be placed back on containers after use.
- Containers of hazardous materials will be stored appropriately away from moving equipment.

At least one spill response kit, to include an appropriate empty container, materials to allow for booming or diking the area to minimize the size of the spill, and appropriate clean-up material (i.e. speedy dri) shall be available at each work site (more as needed).

- All hazardous commodities in use (i.e. fuels) shall be properly labelled.
- Containers shall only be lifted using equipment specifically manufactured for that purpose.
- Drums/containers will be secured and handled in a manner which minimizes spillage and reduces the risk of musculoskeletal injuries.

10.1.5 Safety Accident/Incident Reporting

All accidents and incidents that occur on-site during any field activity will be promptly reported to the SSO and the immediate supervisor.

If any AECOM employee is injured and requires medical treatment, the Site Supervisor will report the incident in accordance with AECOM's incident reporting procedures. A copy of the final Supervisor's Report of Incident will be provided to the SH&E Professional before the end of the following shift.

If any employee of a subcontractor is injured, documentation of the incident will be accomplished in accordance with the subcontractor's procedures; however, copies of all documentation (which at a minimum must include the OSHA Form 301 or equivalent) must be provided to the SSO within 24 hours after the accident has occurred.

All accidents/incidents will be investigated. Copies of all subcontractor accident investigations will be provided to the SSO within five (5) days of the accident/incident.

10.1.6 Environmental Spill/Release Reporting

All environmental spills or releases of hazardous materials (e.g., fuels, solvents, etc.), whether in excess of the Reportable Quantity or not, will be reported according to the sequence identified in the *Site-Specific Spill Reporting Card*. In determining whether a spill or release must be reported to a regulatory agency, the Site Supervisor will assess the quantity of the spill or release and evaluate the reporting criteria against the state-specific reporting requirements, your applicable regulatory permit, and/or client-specific reporting procedures. In order to support the Site Supervisor and expedite the decision to report to a state regulatory agency, a site-specific Spill Reporting Card will be developed. **If reporting to a US state or Federal regulatory agency is required, AECOM has 15 minutes from the time of the spill/release to officially report it.**

Chemical-specific Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Reportable Quantities for the known chemicals onsite are shown in **Table 10.1**.

Table 10.1: CERCLA Reportable Quantities

Hazardous Substance	Regulatory Synonyms	Final RQ (lbs)

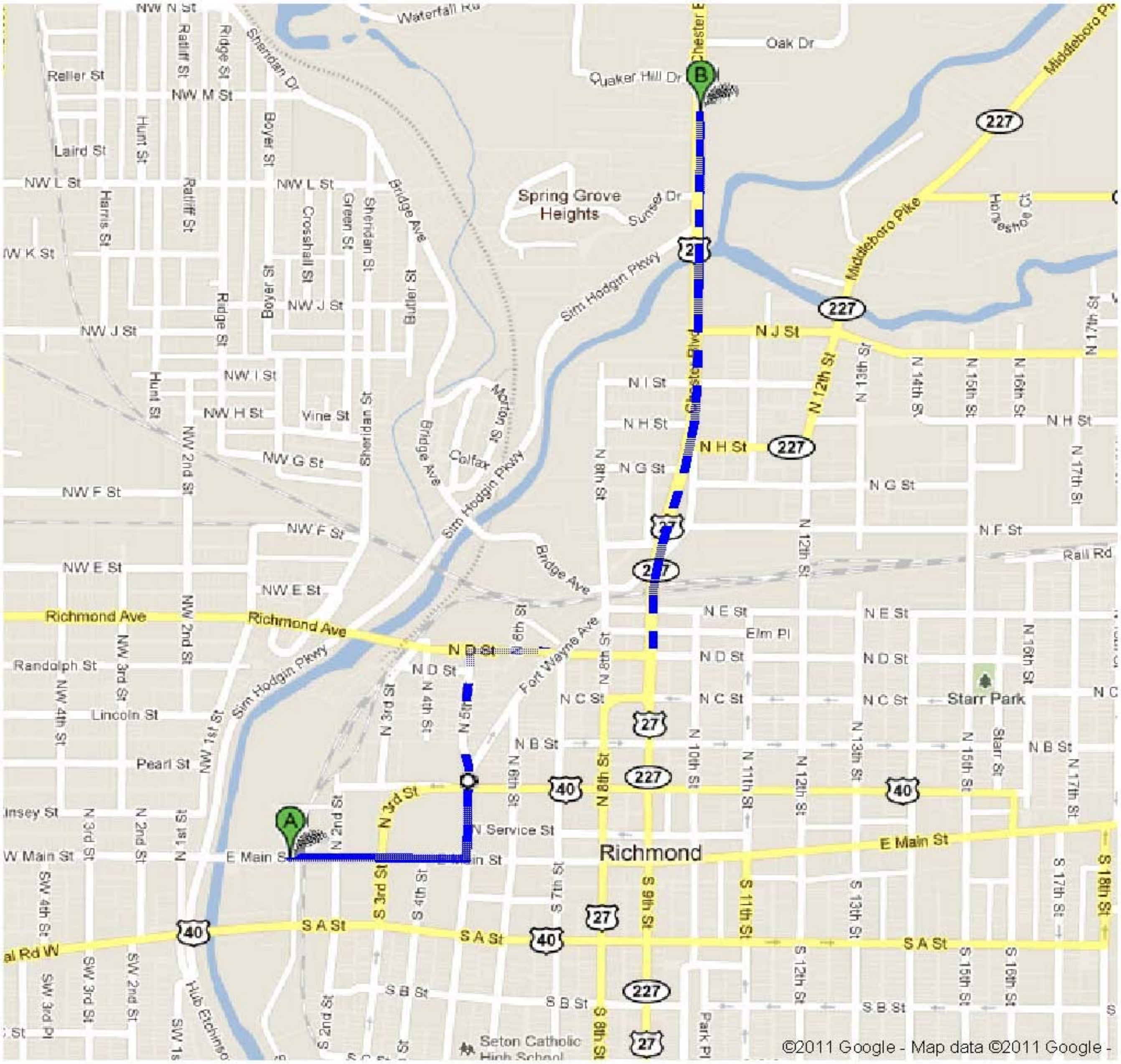
Table 10.1: Emergency Contacts

Emergency Coordinators / Key Personnel			
Name	**Title/Workstation**	**Telephone Number**	**Mobile Phone**
Tony Foster	City of Richmond Executive Director	765-983-7211	765.914.3184
Jeff Nelson	Project Manager / Section Supervisor	812-334-8311	812-322-3205
TBD	Site Supervisor/SSO/EC		
Chad Ross	Regional SH&E Manager		859-512-7774
Brett Hodgson		616-940-4444	616-446-6910
Incident Reporting	**Incident Reporting Line**	**(800) 348-5046**	
Jennifer Williams	Section Supervisor - Indianapolis	317-735-3016	317-313-0212

Organization / Agency	
Name	**Telephone Number**
Police Department (local)	911
Fire Department (local)	911
Ambulance Service ***(EMT will determine appropriate hospital for treatment)***	911
-Emergency Hospital ***(Use by site personnel is only for emergency cases)***	
Reid Hospital	765-983-3000
1401 Chester Blvd.	
Richmond, IN 46131	
Emergency Hospital Route: See **Figure 9-1**	
Poison Control Center	(800) 222-1222
Pollution Emergency	(800) 292-4706
National Response Center	(800) 424-8802
INFOTRAC(insert account number)	(800) 355-5053
Title 3 Hotline	(800) 424-9346

Public Utilities	
Name	**Telephone Number**
Call Before You Dig	811

Figure 10.1: Emergency Occupational Hospital Route/Detail Map



Directions to hospital

Reid Hospital
1401 Chester Boulevard
Richmond, IN 47374

1. Head **east** on **E Main St** toward **S 1st St**
   About 2 mins
   go 0.3 mi

2. Turn left onto **N 5th St**
   About 2 mins
   go 0.3 mi

3. Turn right onto **N D St**
   About 1 min
   go 0.3 mi

4. Turn left onto **IN-227 N/US-27 N**
   Continue to follow US-27 N
   Destination will be on the right
   About 3 mins
   go 0.8 mi

   total 1.7 mi

11.0 Personnel Acknowledgement

By signing below, the undersigned acknowledges that he/she has read and reviewed the AECOM Health and Safety Plan for the site. The undersigned also acknowledges that he/she has been instructed in the contents of this document and understands the information pertaining to the specified work, and will comply with the provisions contained therein.

PRINT NAME	SIGNATURE	ORGANIZATION	DATE

Attachment A

Task Hazard Analyses

AECOM

AECOM
SITE
TASK HAZARD ANALYSIS FORM

ADMINISTRATIVE INFORMATION	
Job/Task Name: **Mobilization/Demobilization**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: 2011/2012	Type of Job/Task: ☐ One time ☒ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

JOB EVENT SEQUENCE
LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE _1_ OF _1_

1. Check weather.	6. Use buddy system when backing up the vehicle.
2. Plan travel path.	7. Follow safe driving procedures
3. Check truck for problems (oil, tires, etc.).	8.
4. Verify you have the appropriate equipment.	9.
5. Secure equipment in truck.	10.

CHEMICAL HAZARDS		**PHYSICAL HAZARDS**	
☐ Asbestos	☐ Bunker fuel/oil	☐ Electricity/High voltage	☐ Ionizing radiation
☐ Acids	☐ Explosives (TNT)	☐ Elevated work areas (fall hazard)	☐ Eye hazards (impact, light, etc.)
☐ Caustics	☐ Dust	☒ Manual materials handling/Back	☒ Slips, trips, and falls
☐ Chlorinated hydrocarbons (TCE)	☐ Dioxins	☐ OE/UXO	☐ Hazardous noise
☐ Lead	☐ Pesticides/Herbicides	☐ Hand tool usage	☐ Heat or cold stress
☐ Gasoline or diesel fuel	☐ MTBE	☐ Power tool usage	☐ Oxygen-deficient atmosphere
☐ BTEX	☐ Methylene chloride	☐ Heavy equipment operations	☐ Oxygen-enriched atmosphere
☐ Jet fuel (JP-4, JP-5, JP-8)	☐ Waste oil	☐ Drill rig (HSA, DP, Air Rotary)	☐ Explosive atmosphere
☐ PCBs	☐ Hydraulic fluid	☐ Excavations (engulfment/collapse)	☐ Powder-actuated tools
☐ Cadmium	☐ Petroleum hydrocarbons	☐ Confined space entry	☒ Vehicular traffic
☐ Compressed gases/asphyxiants	**Other Chemical/Physical Hazards (*List*):** ______		
☐ PAHs			
☐ Welding fumes			
☐ Hydrogen sulfide			
☐ Other metals			

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
☐ Rubber (safety-toe)
☒ Leather (safety-toe)

General:
☐ Coveralls ____________(*type*)
☐ Hearing protection (plugs/muffs)
☐ FF APR __(*cartridges*) if needed
☐ ½-face APR ______(*cartridges*)
☐ Safety harness & lanyard
☐ ANSI-approved hard hat
☐ High-visibility safety vest

Eye Protection:
☐ Faceshield
☐ Safety glasses or goggles
☐ Welder's helmet/goggles

Gloves:
☐ Chemically-protective
__________________(*type*)
☒ Leather/cloth
☐ Welder's
☐ Electrical safety _______(*volts*)

Other (*List*): ______

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

☒ Fire ext. 1A:10B:C (*rating*)
☒ First-aid kit
☐ Dust control/mitigation
☐ Portable eyewash
☐ Fire watch
☐ Traffic control measures

Other (*List*): ______

INSPECT/PERMIT REQUIREMENTS	**EQUIPMENT TO BE USED**

APPLICABLE SOPS (SEE HASP/SSHP/APP)	**TRAINING REQUIREMENTS**
S3NA 005	

AECOM
SITE
TASK HAZARD ANALYSIS FORM

ADMINISTRATIVE INFORMATION	
Job/Task Name: **Site Inspection**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: 2011/2012	Type of Job/Task: ☐ One time ☒ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

JOB EVENT SEQUENCE
LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE _1_ OF _1_

1. Arrive at site.	6.
2. Don appropriate PPE.	7.
3. Walk and/or drive to relevant locations.	8.
4. Note any anomalies or changes in the site since the last field event.	9.
5. Begin work.	10.

CHEMICAL HAZARDS

☐ Asbestos	☐ Bunker fuel/oil
☐ Acids	☐ Explosives (TNT)
☐ Caustics	☐ Dust
☐ Chlorinated hydrocarbons (TCE)	☐ Dioxins
☐ Lead	☐ Pesticides/Herbicides
☐ Gasoline or diesel fuel	☐ MTBE
☐ BTEX	☐ Methylene chloride
☐ Jet fuel (JP-4, JP-5, JP-8)	☐ Waste oil
☐ PCBs	☐ Hydraulic fluid
☐ Cadmium	☐ Petroleum hydrocarbons
☐ Compressed gases/asphyxiants	
☐ PAHs	
☐ Welding fumes	
☐ Hydrogen sulfide	
☐ Other metals	

PHYSICAL HAZARDS

☐ Electricity/High voltage	☐ Ionizing radiation
☐ Elevated work areas (fall hazard)	☒ Eye hazards (impact, light, etc.)
☐ Manual materials handling/Back	☒ Slips, trips, and falls
☐ OE/UXO	☐ Hazardous noise
☐ Hand tool usage	☒ Heat or cold stress
☐ Power tool usage	☐ Oxygen-deficient atmosphere
☐ Heavy equipment operations	☐ Oxygen-enriched atmosphere
☐ Drill rig (HSA, DP, Air Rotary)	☐ Explosive atmosphere
☐ Excavations (engulfment/collapse)	☐ Powder-actuated tools
☐ Confined space entry	☒ Vehicular traffic

Other Chemical/Physical Hazards (*List*): Biting/stinging insects, stray animals, poisonous plants

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
☐ Rubber (safety-toe)
☒ Leather (safety-toe)

General:
☐ Coveralls ____________(*type*)
☐ Hearing protection (plugs/muffs)
☐ FF APR ___(*cartridges*) if needed
☐ ½-face APR ______(*cartridges*)
☐ Safety harness & lanyard
☒ ANSI-approved hard hat
☒ High-visibility safety vest

Eye Protection:
☐ Faceshield
☒ Safety glasses or goggles
☐ Welder's helmet/goggles

Gloves:
☐ Chemically-protective
____________________(*type*)
☐ Leather/cloth
☐ Welder's
☐ Electrical safety _______(*volts*)

Other (*List*):______________________________

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

☒ Fire ext. 1A:10B:C _____(*rating*)	☐ Portable eyewash
☒ First-aid kit	☐ Fire watch
☐ Dust control/mitigation	☐ Traffic control measures

Other (*List*): ______________________________

INSPECT/PERMIT REQUIREMENTS	EQUIPMENT TO BE USED

APPLICABLE SOPS (SEE HASP/SSHP/APP)	TRAINING REQUIREMENTS
	HAZWOPER 40-hour, 8HR Refresher,

AECOM

AECOM
SITE
TASK HAZARD ANALYSIS FORM

ADMINISTRATIVE INFORMATION	
Job/Task Name: **Utility Clearance**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: Fall 2011	Type of Job/Task: ☒ One time ☐ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

JOB EVENT SEQUENCE LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE _1_ OF _1_	
1. Determine project area	6. Mark utilities with pin flags or paint
2. Call in a utility locate request	7.
3. Extend utility markings within project boundary	8.
4. Locate any overhead lines	9.
5. Locate possible underground utilities not marked by outside contractors	10.

CHEMICAL HAZARDS

☐ Asbestos
☐ Acids
☐ Caustics
☐ Chlorinated hydrocarbons (TCE)
☐ Lead
☐ Gasoline or diesel fuel
☐ BTEX
☐ Jet fuel (JP-4, JP-5, JP-8)
☐ PCBs
☐ Cadmium
☐ Compressed gases/asphyxiants
☐ PAHs
☐ Welding fumes
☐ Hydrogen sulfide
☐ Other metals
☐ Bunker fuel/oil
☐ Explosives (TNT)
☐ Dust
☐ Dioxins
☐ Pesticides/Herbicides
☐ MTBE
☐ Methylene chloride
☐ Waste oil
☐ Hydraulic fluid
☐ Petroleum hydrocarbons

PHYSICAL HAZARDS

☐ Electricity/High voltage
☐ Elevated work areas (fall hazard)
☐ Manual materials handling/Back
☐ OE/UXO
☒ Hand tool usage
☐ Power tool usage
☐ Heavy equipment operations
☐ Drill rig (HSA, DP, Air Rotary)
☐ Excavations (engulfment/collapse)
☐ Confined space entry
☐ Ionizing radiation
☐ Eye hazards (impact, light, etc.)
☒ Slips, trips, and falls
☐ Hazardous noise
☒ Heat or cold stress
☐ Oxygen-deficient atmosphere
☐ Oxygen-enriched atmosphere
☐ Explosive atmosphere
☐ Powder-actuated tools
☒ Vehicular traffic

Other Chemical/Physical Hazards (*List*): Paint fumes, insect bites/stings, stray animals, poisonous plants

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
☐ Rubber (safety-toe)
☒ Leather (safety-toe)

General:
☐ Coveralls ____________(*type*)
☐ Hearing protection (plugs/muffs)
☐ FF APR ___(*cartridges*) if needed
☐ ½-face APR ______(*cartridges*)
☐ Safety harness & lanyard
☐ ANSI-approved hard hat
☐ High-visibility safety vest

Eye Protection:
☐ Faceshield
☒ Safety glasses or goggles
☐ Welder's helmet/goggles

Gloves:
☐ Chemically-protective ____________________(*type*)
☐ Leather/cloth
☐ Welder's
☐ Electrical safety _______(*volts*)

Other (*List*):______________________________

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

☒ Fire ext. 1A:10B:C_____(*rating*)
☒ First-aid kit
☐ Dust control/mitigation
☒ Portable eyewash
☐ Fire watch
☐ Traffic control measures

Other (*List*): ______________________________

INSPECT/PERMIT REQUIREMENTS	**EQUIPMENT TO BE USED**

APPLICABLE SOPS (SEE HASP/SSHP/APP)	**TRAINING REQUIREMENTS**
	HAZWOPER 40-hour, 8HR Refresher, Biological Awareness Training

AECOM
SITE
TASK HAZARD ANALYSIS FORM

ADMINISTRATIVE INFORMATION	
Job/Task Name: **Excavation Oversight**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: Fall 2011	Type of Job/Task: ☒ One time ☐ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

JOB EVENT SEQUENCE LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE _1_ OF __	
6. Mobilize.	11. Stay in full view of the equipment operator and maintain a distance of at least 25 feet from the excavator and 10 feet from the edge of the excavation.
7. Don appropriate PPE.	12. Take confirmation soil samples from the basket of the excavator (as necessary).
8. Perform tailgate safety meeting.	13. Stop work. Outline the excavation with orange fencing, caution tape, etc.
9. Establish work zones/barricades.	14. Cover any stockpiles with plastic sheeting.
10. Start excavation work.	15. Demobilize.

CHEMICAL HAZARDS		PHYSICAL HAZARDS	
☐ Asbestos	☐ Bunker fuel/oil	☐ Electricity/High voltage	☐ Ionizing radiation
☐ Acids	☐ Explosives (TNT)	☐ Elevated work areas (fall hazard)	☒ Eye hazards (impact, light, etc.)
☐ Caustics	☐ Dust	☐ Manual materials handling/Back	☒ Slips, trips, and falls
☐ Chlorinated hydrocarbons (TCE)	☐ Dioxins	☐ OE/UXO	☒ Hazardous noise
☒ Lead	☐ Pesticides/Herbicides	☐ Hand tool usage	☒ Heat or cold stress
☐ Gasoline or diesel fuel	☐ MTBE	☐ Power tool usage	☐ Oxygen-deficient atmosphere
☒ BTEX	☐ Methylene chloride	☒ Heavy equipment operations	☐ Oxygen-enriched atmosphere
☐ Jet fuel (JP-4, JP-5, JP-8)	☐ Waste oil	☐ Drill rig (HSA, DP, Air Rotary)	☐ Explosive atmosphere
☐ PCBs	☐ Hydraulic fluid	☒ Excavations (engulfment/collapse)	☐ Powder-actuated tools
☐ Cadmium	☐ Petroleum hydrocarbons	☐ Confined space entry	☐ Vehicular traffic
☐ Compressed gases/asphyxiants	**Other Chemical/Physical Hazards (*List*):** biological hazards, small animals		
☒ PAHs			
☐ Welding fumes			
☐ Hydrogen sulfide			
☒ Other metals			

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED		OTHER SAFETY EQUIPMENT/CONSIDERATIONS	
Boots:	**Eye Protection:**	☒ Fire ext. 1A:10B:C (*rating*)	☒ Portable eyewash
☐ Rubber (safety-toe)	☐ Faceshield	☒ First-aid kit	☐ Fire watch
☒ Leather (safety-toe)	☒ Safety glasses or goggles	☐ Dust control/mitigation	☐ Traffic control measures
General:	☐ Welder's helmet/goggles	**Other (*List*):** ____	
☐ Coveralls ____ (*type*)	**Gloves:**	**INSPECT/PERMIT REQUIREMENTS**	**EQUIPMENT TO BE USED**
☐ Hearing protection (plugs/muffs)	☒ Chemically-protective		
☐ FF APR __ (*cartridges*) if needed	Nitrile (*type*)		
☐ ½-face APR ____ (*cartridges*)	☒ Leather/cloth		
☐ Safety harness & lanyard	☐ Welder's		
☒ ANSI-approved hard hat	☐ Electrical safety ____ (*volts*)		
☒ High-visibility safety vest			
Other (*List*): ____			

APPLICABLE SOPs (SEE HASP/SSHP/APP)	TRAINING REQUIREMENTS
S3NA 002, 208, 303, 309, 313, 417, 502, 510, 513	HAZWOPER 40-hour training, 8-hour Refresher

MONITORING PROCEDURES
See Ambient Air Monitoring Plan (AAMP, Appendix F of the RAWP).

AECOM
SITE
TASK HAZARD ANALYSIS FORM

ADMINISTRATIVE INFORMATION	
Job/Task Name: **Ground Water Sampling**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: 2011/2012	Type of Job/Task: ☐ One time ☒ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

JOB EVENT SEQUENCE
LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE _1_ OF _2_

1. Check the weather.	6. Gauge static water level.
2. Mobilize with equipment and supplies.	7. Decontaminating water level meter or interface probe.
3. Conduct tailgate meeting and site walk (reconnaissance).	8. Set up equipment at each well site.
4. Drive and/or walk to well locations.	9. Lower tubing and submersible pump down well casing.
5. Open well casings/flush mount covers.	10. Turn on equipment.

CHEMICAL HAZARDS		PHYSICAL HAZARDS	
☐ Asbestos	☐ Bunker fuel/oil	☐ Electricity/High voltage	☐ Ionizing radiation
☐ Acids	☐ Explosives (TNT)	☐ Elevated work areas (fall hazard)	☒ Eye hazards (impact, light, etc.)
☐ Caustics	☐ Dust	☒ Manual materials handling/Back	☒ Slips, trips, and falls
☐ Chlorinated hydrocarbons (TCE)	☐ Dioxins	☐ OE/UXO	☒ Hazardous noise
☐ Lead	☐ Pesticides/Herbicides	☒ Hand tool usage	☒ Heat or cold stress
☐ Gasoline or diesel fuel	☐ MTBE	☐ Power tool usage	☐ Oxygen-deficient atmosphere
☒ BTEX	☐ Methylene chloride	☐ Heavy equipment operations	☐ Oxygen-enriched atmosphere
☐ Jet fuel (JP-4, JP-5, JP-8)	☐ Waste oil	☐ Drill rig (HSA, DP, Air Rotary)	☐ Explosive atmosphere
☐ PCBs	☐ Hydraulic fluid	☐ Excavations (engulfment/collapse)	☐ Powder-actuated tools
☐ Cadmium	☐ Petroleum hydrocarbons	☐ Confined space entry	☒ Vehicular traffic
☐ Compressed gases/asphyxiants			
☒ PAHs			
☐ Welding fumes			
☐ Hydrogen sulfide			
☒ Other metals			

Other Chemical/Physical Hazards (*List*): **decon solutions, severe weather, sunburn, pinch points, spark hazard or electric shock, sharp materials, spills and biological hazards**

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
- ☐ Rubber (safety-toe)
- ☒ Leather (safety-toe)

General:
- ☐ Coveralls ____________(*type*)
- ☒ Hearing protection (plugs/muffs as needed)
- ☐ FF APR ___(*cartridges*) if needed
- ☐ ½-face APR ______(*cartridges*)
- ☐ Safety harness & lanyard
- ☒ ANSI-approved hard hat
- ☒ High-visibility safety vest

Eye Protection:
- ☐ Faceshield
- ☒ Safety glasses or goggles
- ☐ Welder's helmet/goggles

Gloves:
- ☒ Chemically-protective Nitrile gloves __________(*type*)
- ☒ Leather/cloth (as needed)
- ☐ Welder's
- ☐ Electrical safety _______(*volts*)

Other (*List*):

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

- ☒ Fire ext. 1A:10B:C _____(*rating*)
- ☒ First-aid kit
- ☐ Dust control/mitigation
- ☒ Portable eyewash
- ☐ Fire watch
- ☐ Traffic control measures

Other (*List*):

INSPECT/PERMIT REQUIREMENTS	EQUIPMENT TO BE USED
	Water level meter, low-flow electric pump, car battery, tubing, field chemistry equipment (quanta), hand tools

APPLICABLE SOPS (SEE HASP/SSHP/APP)	TRAINING REQUIREMENTS
S3NA 002, 208, 313, 314, 417, 502, 505, 513	HAZWOPER 40-hour training, 8-hour Refresher

ADMINISTRATIVE INFORMATION	
Job/Task Name**: Ground Water Sampling**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: 2011/2012	Type of Job/Task: ☐ One time ☒ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

JOB EVENT SEQUENCE (CONT'D) LIST ONE STEP OF THE JOB FOR EACH LINE. PAGE 2 OF 2
11. Develop water from well casing.
12. Transport purge water to disposal container/area.
13. Breakdown and decontaminate equipment.
14. Secure equipment in vehicle.
15. Demobilize.
16.
17.
18.
19.
20.

MONITORING PROCEDURES
As required by the SSO.

AECOM
RICHMOND FORMER MGP SITE
TASK HAZARD ANALYSIS FORM

ADMINISTRATIVE INFORMATION	
Job/Task Name**: Mobilization/Demobilization, Site Inspection, Utility Clearance, Excavation Oversight, Ground Water Sampling**	
Project Name: Richmond Former MGP Site	Project Location: Richmond, IN
Project Manager: Jeff Nelson	Analysis performed by: Katie Dubec
Date Job/Task to be performed: 2011/2012	Type of Job/Task: ☒ One time ☒ Routine job/task
Responsible Organization: AECOM	Job Supervisor: TBD

I HAVE READ OR BEEN BRIEFED ON THE HAZARDS AND PROTECTIVE MEASURES IDENTIFIED FOR THE ABOVE-LISTED JOB/TASK AND FULLY UNDERSTAND THE JOB/TASK-SPECIFIC REQUIREMENTS THAT HAVE BEEN ESTABLISHED FOR IT.

DATE	EMPLOYEE NAME	EMPLOYEE SIGNATURE	EMPLOYER NAME

[attach THAs]

Attachment B

Material Safety Data Sheets

[attach MSDSs]

Attachment C

Applicable SH&E SOPs

[attach SOPs]

Appendix F

Quality Assurance Project Plan

Prepared for:
City of Richmond

Prepared by:
AECOM
Bloomington, Indiana
September 2011

Quality Assurance Project Plan
Richmond Gas Plant
16 East Main Street
Richmond, Indiana
Brownfields No. 4980004

AECOM

Prepared for:
City of Richmond

Prepared by:
AECOM
Bloomington, Indiana
September 2011

Quality Assurance Project Plan
Richmond Gas Plant
16 East Main Street
Richmond, Indiana
Brownfields No. 4980004

Nathan Conniff

Prepared By: Nathan Conniff, Environmental Scientist

Jeffy P. Nelson

Reviewed By: Jeffrey Nelson, Department Manager - Indiana

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1.0 Introduction

The Indiana Department of Environmental Management (IDEM) requires that all environmental monitoring and measurement efforts participate in a centrally managed quality assurance (QA) program.

Any party generating data under this program has the responsibility to implement minimum procedures to assure that the precision, accuracy, completeness and representativeness of its data are known and documented. To ensure the responsibility is met uniformly, each party must prepare a written QA Project Plan (QAPP) covering each project it is to perform.

This QAPP presents the organization, objectives, functional activities and specific quality assurance (QA) and quality control (QC) activities associated with the Remedial Activities for the site. This QAPP also describes the specific protocols which will be followed for sampling, sample handling and storage, chain of custody, and laboratory (and field) analysis.

All QA/QC procedures will be in accordance with applicable professional technical standards, IDEM requirements, government regulation and guidelines, and specific project goals and requirements. This QAPP has been prepared by AECOM on behalf of the City of Richmond as part of the removal activities planned for the Site.

This QAPP is **Appendix F** of the Removal Action Work Plan (RAWP) for the former manufactured gas plant (MGP) site located in Richmond, Indiana (see **Figure 1** of the RAWP). Remedial activities will be performed in accordance with the RAWP as a step toward the overall objective of ensuring that exposure to affected media is controlled sufficiently to protect future receptors: construction workers and recreational patrons. The Quality Assurance Manual (QAM) for the laboratory is provided as **Appendix F-1** of this QAPP.

2.0 Project Description

2.1 Site Location / Background Information

The former Richmond MGP site originally covered an area of 2.26 acres and has been divided into three separate parcels since cessation of MGP operations. The eastern and central parcels, covering 0.44 and 0.38 acres respectively, are owned by the Indiana Gas Company located east of the C & O Railroad. The western parcel (Site), covering 1.429 acres, is owned by the City of Richmond. The Site is located on the southwest corner of Johnson Street and North 2nd Street in Richmond, Wayne County, Indiana. The site location is shown in **Figure 1** of the RAWP. The Site is bounded by the following properties:

- To the north by Johnson Street.
- To the east, by railroad tracks beyond which are the two parcels owned by IGC/Vectren;
- To the south by East Main Street. Commercial property is located south of East Main Street.
- To the west by a vacant lot covered with grass-like vegetation.

All buildings on the Site were demolished in 2009. The Site is currently vacant and heavily vegetated. The site layout is shown in **Figure 2**. Land use on adjacent properties is characterized as nonresidential. The nearest surface water body is the East Fork of the Whitewater River, located about 400 feet west of the Site. General surface topography of the site slopes to the west.

2.2 Past Data Collection Activities

Past data collection activities associated with the facility are discussed in Section 2.2 of the RAWP.

2.3 Project Scope and Objectives

The overall objective of this remediation is to ensure that exposure to affected media is controlled sufficiently to protect future receptors: construction workers and recreational patrons. Sampling and analysis protocol presented herein are intended to satisfy the requirements set forth in the IDEM Risk Integrated System of Closure (RISC) Technical and User Guides and presented in the RAWP. The removal action will The proposed removal action(s) will address potential direct contact exposure to surface soils within the footprint of source areas; and will remove source materials and or heavily affected soils that could present a continuing source and degrade water quality. The areas subject to active remediation are depicted on **Figure 12** of the RAWP. Samples will be collected from the limits of the excavations to document concentrations of COCs at the limits of excavation and for further Site delineation. Reports summarizing the results of previous investigations are discussed in the RAWP.

Data quality must be sufficient to allow comparison of the concentration of hazardous COCs in soil to the cleanup levels summarized in **Table 2** of the RAWP. All analytical methods have been selected to provide quantitative determination of the target analytes at detection limits sufficiently low to facilitate application of the data for comparison with the cleanup levels established in the RAWP.

2.4 Sample Network Design and Rationale

2.4.1 Site Maps and Sampling Locations

Site maps showing the layout of the facility, the locations of current and historic site features, and locations of previous sampling points are shown in **Figure 2**, **Figure 3**, and **Figure 4**, respectively, of the RAWP.

2.4.2 Rationale for Selected Remediation Locations

Sampling strategy and rationale for the remediation actions at the former MGP site are discussed in Sections 3 and 4 of the RAWP.

2.4.3 Sample Network Summary Table

An estimated sampling schedule to be conducted during the remediation is shown in **Table F-1** herein.

2.5 Parameters to be Tested and Frequency

The media and COC to be addressed during the remediation are presented in **Table 2** of the RAWP. The frequency of sampling is summarized in **Table F-1**.

2.6 Intended Data Usage and Data Quality Objectives

2.6.1 Project Target Parameters and Intended Data Usages

To accomplish the project objectives, a high level of data quality is required. Laboratory analyses will require full documentation of analytical methods and sample preparation steps, data packages, and data validation procedures necessary to provide defensible data in support of clean closure. Since this remediation will include comparison of analytical results to the proposed cleanup levels presented in **Table 2** of the RAWP, analytical methods are necessary which have anticipated detection limits below these goals.

2.6.1.1 Field Parameters

Field measurements and intended data usages are listed below:

Field Measurement	Use
Volatile organic compounds in parts per million, as dictated by a field photoionization detector	Screening of soil for segregation according to appropriate treatment/disposal methods
Visual and olfactory observations	Inspection of soil for segregation according to appropriate treatment/disposal methods

2.6.1.2 Laboratory Parameters

Laboratory measurements and intended data usages are listed below:

Laboratory Measurement	Use
Benzene in source material/affected soil	Characterization for proper handling, blending, disposal
COCs in stockpiled soil	Evaluation of suitability for use as backfill or need for treatment/disposal/destruction
COCs in confirmatory soil samples	Verification of removal of source material/affected soil, documentation of concentrations of COCs at the limits of excavation, and for further Site delineation.

Target laboratory parameters for the Site were selected based upon historical use at the facility and previous sampling and analysis. A detailed discussion of previous analytical data and parameter selection is provided in Section 2.2 of the RAWP.

A summary of laboratory analyses, analytical methods and sample matrices identified for this remedial action is presented in **Table F-1**.

2.6.2 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the quality of the data required to support decisions made during remediation activities. DQOs are based on the end uses of the data to be collected; therefore, data collected for different end uses may have different DQOs. For the purposes of this remedial action, three DQO Levels are established. Level I defines objectives for field-generated (real-time monitoring) data. Level III defines objectives for off-site laboratory analytical data obtained for site characterization. Level IV defines objectives for off-site laboratory analytical data obtained for confirmation of remediation completion.

Field data for soil screening will be generated under DQO Level I. These data will be generated using the procedures set forth in the field SOPs using portable instruments. These procedures will yield rapid qualitative screening results suitable for use in field-based decisions regarding health and safety as well as additional, more rigorous sampling and/or analysis.

Laboratory analyses for characterization of soil will be performed under DQO Level III. These data will be generated using laboratory methods conforming to procedures and specifications given in SW-846, and will provide an intermediate level of data quality.

Laboratory analytical data for soil confirmation sampling will be generated under DQO Level IV, designed to ensure maximum quality control. Specific analytical laboratory QA/QC criteria for accuracy and precision are associated with Level IV data. These data will be generated using laboratory methods conforming to procedures and specifications given in SW-846. Sample preparation and analytical methods, data packages and validation procedures employed will be sufficient to produce defensible data. Specific analytical QA/QC criteria established for DQO Level IV activities are contained in the laboratory Quality Assurance Manual (**Appendix F-1**).

It is anticipated that occasional unique sample conditions beyond the control of sampling and analytical personnel may result in incidental occurrences of elevated detection limits for certain compounds in those samples. Incidents of excessive concentration of a particular constituent in a given sample or anomalous matrix characteristics may, in these instances, limit the ability of the analytical laboratory to reach the DQOs, as stated.

2.7 Project Schedule

The anticipated project schedule is discussed in Section 7 of the RAWP.

3.0 Project Organization and Responsibility

3.1 Project Organization

Figure F-1 shows the project organization and line of authority for this project. This figure includes all individuals discussed below.

3.2 Management Responsibilities

3.2.1 City of Richmond Executive Director

The City of Richmond Executive Director will be the primary contact between IDEM and AECOM for this project. All submittals and project-specific information from City of Richmond and AECOM will be reviewed and approved by the Executive Director before being forwarded. The Executive Director is responsible for the review and approval of all AECOM project plans and invoices. The Executive Director will:

- Approve all reports and other deliverables prior to submittal to IDEM;
- Ultimately be responsible for the quality of interim and final reports; and
- Represent the City of Richmond and contractor at meetings.

3.2.2 Indiana Brownfields Project Manager

The Indiana Brownfields Project Manager (PM) will be the primary government contact between the IDEM and City of Richmond for this project. The Indiana Brownfields PM will coordinate applicable project-specific information sent from other branches of IDEM to City of Richmond. The Indiana Brownfields PM will also be responsible for coordinating the review and approval of all submittals from City of Richmond, and will have final approval of all submittals.

3.2.3 AECOM Project Manager

The AECOM Project Manager (AECOM PM) will be responsible for implementing all technical phases of this removal action, and will report directly to the City of Richmond Executive Director. He will ensure that all AECOM deliverables meet project objectives and quality standards. The AECOM PM is responsible for technical quality control and project oversight. He will assist the Executive Director by writing and distributing this QAPP to all parties connected with the project, including the laboratory.

3.3 Quality Assurance Officer Responsibilities

The QA/QC Officer will report directly to the AECOM PM. The QA/QC Officer is responsible for implementing the QA/QC field program outlined in this QAPP, ensuring data validation completeness, providing internal field performance and system audits, and for ensuring that all QA/QC field procedures for this project are being followed. He will coordinate with the Laboratory Project Chemist to ensure that all sample results from the analytical laboratory are validated. He will write QA/QC sections for deliverables as required.

3.4 Laboratory Responsibilities

The following laboratory will have the responsibility of analyzing the samples collected during this removal action project:

Pace Analytical Services, Inc.
7726 Moller Road
Indianapolis, Indiana 46268-4163

Project organization for the laboratory is defined in the laboratory Quality Assurance Manual (**Appendix F-1**).

3.5 Field Responsibilities

3.5.1 AECOM Health and Safety Officer

The Health and Safety Officer reports directly to the AECOM PM and will be responsible for implementing the approved Health and Safety Plan (**Appendix D** of the RAWP).

3.5.2 AECOM Field Team Leader (Construction Manager)

The Construction Manager will report directly to the AECOM PM. He will be responsible for coordinating the day-to-day activities of the various field personnel under his supervision. He is responsible for the following:

- Implementing field-related work plans, assurance of schedule compliance and adherence to management-developed study requirements;
- Coordinating and managing field staff activities;
- Adhering to work schedules provided by the AECOM PM;
- Writing and approving text and graphics required for field team efforts;
- Coordinating and overseeing the technical efforts of subcontractors;
- Identifying problems at the field level, resolving field problems with the laboratory, implementing and documenting corrective action procedures, and providing communication between field personnel and upper management; and
- Assisting with the preparation of draft and final deliverables.

3.6 Responsibility for Activities

Table F-2 lists the major activities for the remediation, along with the responsible person and the location where the work is to be performed.

4.0 Quality Assurance Objectives for Measurement of Data

4.1 Level of Quality Control Effort

Method blanks, field duplicates, laboratory replicates, standard reference materials, and matrix spikes will be analyzed to assess the quality of the data resulting from the field sampling and analytical programs where necessary to support DQO Levels III and IV. Equipment blanks will be analyzed as part of this removal action only when re-useable sampling equipment is employed. Trip blanks, consisting of organic-free deionized water in 40 milliliter (mL) vials will accompany every shipment of confirmation samples for volatile organic compounds (VOCs). No field QA/QC samples will be collected for waste characterization or backfill characterization.

Method blanks are generated within the laboratory and used to assess contamination resulting from laboratory procedures.

Duplicate samples are field samples analyzed to check for sampling and analytical reproducibility. Replicate samples within the laboratory are analyzed to check for analytical reproducibility.

Duplicate samples will be collected at a rate of one duplicate sample for every ten or fewer field samples of a given matrix.

Matrix spikes (MS) provide information about the effect of the sample matrix on the digestion and measurement methodology. All matrix samples are performed in duplicate and are hereafter referred to as MS/MSD samples. They are collected for organic analyses only.

MS/MSD samples will be collected at a rate of one MS/MSD sample for every twenty or fewer field samples of a given matrix. Soil MS/MSD samples require no extra volume collected.

4.2 Accuracy, Precision and Completeness of Analysis

4.2.1 Accuracy

Accuracy is the level of agreement between a sample and an accepted reference value. Accuracy in the field is assessed through the use of equipment blanks and trip blanks, and through adherence to all guidelines pertaining to decontamination, sample handling, preservation and holding times. In the laboratory, accuracy is assessed through the analysis of matrix spikes (MS) or Standard Reference Materials (SRM), and the calculation of percent recoveries. The equation to determine percent recovery is located in Section 13 of this QAPP, and the accuracy control goals are shown in the laboratory Quality Assurance Manual (**Appendix F-1**).

4.2.2 Precision

Precision is a measure of the degree to which two or more measurements are in agreement. Field precision of analytical samples will be assessed through the collection and measurement of field duplicates at a rate of one duplicate per ten analytical samples. The estimated number of field duplicates for this project is found in **Table F-1**.

Laboratory precision is assessed through the analysis of three or more replicate samples. Precision is assessed through the calculation of Relative Percent Difference (RPD). The equations for these measurements are located in Section 13 of the QAPP and precision control goals are presented in the Laboratory Quality Assurance Manual (**Appendix F-1**).

4.2.3 Completeness

Completeness is a measure of the amount of valid data obtained from a project-specific data collection system compared with the amount of valid data that was expected to be obtained from the system under normal circumstances. The equation for completeness is located in Section 13 of the QAPP. Field completeness for this project is expected to be greater than 90 percent. Laboratory completeness for this project is expected to be greater than 95 percent.

4.3 Qualitative QA Objectives

4.3.1 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent environmental conditions at the site. Representativeness in the field is dependent upon proper design of the sampling program. The sampling program, discussed in Section 3 of the RAWP, was designed to provide data representative of facility conditions. During the development of this program, consideration was given to existing analytical data, physical setting, manufacturing processes, and constraints inherent in the system. The representativeness criterion will be satisfied by ensuring that the RAWP is followed, and that proper sampling protocols are followed at all times.

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicate samples.

4.3.2 Comparability

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability between sets of field data will be dependent upon the similarity of properly designed field sampling programs, and similarity of field sampling techniques. Planned laboratory analytical data will be comparable when similar sampling and analytical methods are used and documented. Comparability is also dependent upon similar QA/QC objectives.

5.0 Sampling Procedures

5.1 Sampling Summary

Sampling procedures are described in Section 3 of the RAWP.

The following field QA/QC samples will be collected:

Sample Type	Matrix	Analysis	Frequency
Duplicates	Soil	BTEX SVOCs Metals(1) Cyanide	1 per 10 samples
MS/MSD	Soil	BTEX SVOCs Metals Cyanide	1 per 20 samples
Blanks	organic-free deionized water	BTEX SVOCs Metals Cyanide	1 per day (1 per 10 samples when reusable equipment is employed)
Trip Blanks	organic-free deionized water	BTEX	1 per shipping container

(1) Metals include arsenic, antimony, beryllium, cadmium, chromium, lead, mercury, nickel, selenium and vanadium.

All field duplicates and MS/MSDs will be collected and handled following the same sampling procedures as described for the investigative samples. Sample containers used to collect the field duplicate and MS/MSD samples will be identical to those used to collect the confirmation samples for that particular matrix and analysis. The methods used to handle and analyze these samples will be identical to the methods used for the confirmation samples. A summary of the field duplicate and MS/MSD samples to be collected and their subsequent analysis is presented in **Table F-1**. Field banks will be taken as part of the investigative sampling activities only when reusable sampling equipment is employed in the process. No field QA/QC samples will be collected for waste characterization or backfill characterization.

Trip blanks will accompany samples submitted to the laboratory for analysis of BTEX. Each trip blank will consist of two 40 mL vials filled with organic-free deionized water so that no air space is present in each vial. The trip blanks will remain with the VOC sample bottles as samples are being collected. One trip blank sample set will be sent with each shipping container that contains samples analyzed for VOCs. The trip blank will be analyzed for BTEX.

5.2 Sample Containers, Packing, and Handling

Sample containers, preservatives, and holding times are specified in the laboratory Quality Assurance Manual (**Appendix F-1**). Standard pre-cleaned sample containers that will be used to collect soil samples will be obtained from the laboratory. Following sample collection, the bottle lids will be tightened, and all pertinent data about the sample will be recorded in a field notebook or on field sampling forms. Sample labels will be filled out and affixed to the sample containers after filling. Samples will be packed and shipped in accordance with AECOM SOP 54230-SI-SOP-09 (**Appendix F-2**).

5.3 Equipment Decontamination

All reusable sampling equipment used to collect investigative samples will be decontaminated before each use. Specific procedures for decontamination are described in AECOM SOP 9903-FSP-SOP-13 (**Appendix F-2**). In general, only equipment that comes in direct contact with the medium to be sampled will be decontaminated. Decontamination will consist of a non-phosphate detergent solution wash (e.g., *Liquinox* and water), deionized water rise, and air drying. Wastes generated during decontamination will be containerized on-site. The proper characterization and disposal of these materials will be handled separately using a certified waste disposal contractor.

Clean, disposable sampling equipment will be used to collect analytical samples directly from the excavator bucket. Upon completion of the remedial action, non-dedicated equipment, such as excavation equipment, hand tools, etc., will be decontaminated on-site prior to leaving the facility. Decontamination will consist of building a temporary decontamination pad at the facility with the capability of temporarily holding decontamination fluids and solid waste. All equipment that comes in direct contact with waste soil will be decontaminated before leaving the Site using a high pressure steam cleaner. Wastes generated during decontamination will be containerized on-site. The proper characterization and disposal of these materials will be handled separately using a certified waste disposal contractor.

To obtain reliable and credible soil analytical data and to prevent possible cross contamination during sampling, the following precautions will be followed:

- All sample containers will remain closed until samples are collected;
- Sampling equipment will remain sealed until samples are collected;
- Clean or decontaminated inner surfaces of sampling equipment will not be allowed to come in contact with the ground, nor will surfaces be touched by samplers; and
- Samplers will wear clean, disposable nitrile gloves.

6.0 Chain-of-Custody

Custody is one of several factors necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy two major requirements for admissibility (relevance and authenticity). Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files, including all originals of laboratory reports and purge files that are maintained under document control in a secure area.

A sample or evidence file is under custody if:

- The item is in actual possession of a person; or
- The item is in view of the person after being in actual possession of the person; or
- The item was in actual physical possession but is locked up to prevent tampering; or
- The item is in a designated and identified secure area.

6.1 Field Specific Chain-of-Custody Procedures

6.1.1 Initiation of Chain-of-Custody Field Procedures

Prior to beginning field activities, all field and supervisory personnel will be instructed in proper record keeping and chain-of-custody procedures. Upon beginning sampling activities in the field, all necessary sample labels are distributed to field personnel by the AECOM PM (or designated participant). Sample labels will include the following information:

- Sample number/identification;
- Date - month, day and year;
- Time - Indicating the time of sample collection;
- Preservative - type of preservative used, or "none", as appropriate;
- Samplers - Each sampler's name or initials; and
- Remarks - Indicates the type of analysis to be performed.

Self-adhering sample labels will be affixed directly to the containers. After collection and identification, the sample will remain under chain-of-custody.

6.1.2 Field Logbooks/Documentation

All field activities, observations, and data will be recorded in a bound log book. Log book entries will contain sufficient detail that the activities recorded can be reconstructed at a later date without reliance on memory. Bound log books will be used to record:

- The date and time of the activity recorded;
- Weather conditions;
- Names of individuals present;

- Level of personal protection used; and
- Identification of visitors (and the purpose of the visit) to the work area.

Entries will be made in permanent ink, and signed by the person making the entry. Incorrect entries will be crossed out with a single line, then initialed and dated by the person making the correction. A record of sampling and/or data collection activities will include:

- The location of the sampling/measurement station (including distance measurement, grid coordinates, etc. as appropriate);
- A record of any photographs taken; and
- A listing of all equipment used in the collection activity and decontamination details.

A sample is physical evidence collected from the environment. Because of the potential evidentiary nature of sample-collecting investigations, the possession of samples must be traceable from the time the samples are collected until they are received and analyzed by the laboratory. Chain-of-custody procedures are used to maintain and document sample possession. The principal forms used to identify samples and to document possession are sample labels and chain-of-custody records.

6.1.3 Transfer of Custody and Shipment Procedures

The sample packaging and shipment procedures summarized below will ensure that the samples arrive at the laboratory with chain-of-custody intact. The following chain-of-custody procedures will be followed.

- To the extent possible, the quantity and types of samples and sample locations will be determined prior to actual field work. As few people as possible will handle samples.
- The team member conducting the sampling will be personally responsible for the care and custody of the collected samples until the samples are properly transferred or dispatched.
- Sample labels will be completed for each sample, using waterproof ink.
- The Project Manager will review all field activities to determine whether proper custody procedures were followed during the field work, and decide if additional samples are required.

The following procedures will be followed for transfer of sample custody and sample shipment.

- Samples will be accompanied by a chain-of-custody record. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record will document sample custody transfer from the sampler, often through another person, to the analyst.
- Samples will be packaged in coolers with sufficient packing material to ensure safe shipment of glass containers. Ice will be included to maintain sample temperatures at a maximum of 4^{o}C.
- Properly packaged samples will be picked up by the laboratory or dispatched by overnight courier to the laboratory for analysis, with custody records accompanying each shipment. Shipping containers will be locked or secured with a custody seal for shipment to the laboratory. Custody seals will be covered with clear tape. The method of shipment, courier name(s) and other pertinent information will be entered in the "Remarks" section of the chain-of-custody record form.

- The original chain-of-custody records will accompany the samples in shipment. The Project Manager will retain a copy of each chain-of-custody record and each shipping receipt.

Unless prohibited by weather conditions, all original data will be recorded with waterproof ink in bound log books, and on field data sheets, sample labels and chain-of-custody records.

If an error is made on an accountable document assigned to one individual, that individual may make corrections by drawing a single line through the error and recording the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All subsequent corrections must be initialed and dated.

6.2 Laboratory Chain-of-Custody and Records

All samples will be received at the laboratory by the Sample Custodian. It will be the responsibility of the Sample Custodian to determine:

- Whether or not the samples require chain-of-custody;
- Whether or not the samples are labile in nature and require immediate attention; and
- The manner in which those samples will be split, preserved, and stored or routed.

It is the objective of the Sample Custodian to ensure that all pertinent information relative to those samples is recorded. The information may be used in client reports, communicated to the laboratory or to the client and, in some cases, reported to a legal authority relative to chain-of-custody samples.

The Sample Custodian is responsible for the receipt, log-in, and storage of all client samples at the laboratory. Each sample is labeled with a unique number which is entered into the sample receiving log and Laboratory Information Management System (LIMS) system. The samples are placed into appropriate storage within an access controlled location. All samples are maintained under proper storage conditions for thirty days past the generation of the analytical report.

A chain-of-custody sample control record is used as the documentation for the movement of chain-of-custody samples in and out of the access controlled storage. The analyst signs samples in and out each time a sample is removed for any analysis. After all analyses are completed, the Sample Custodian files the form with the chain-of-custody into the final evidence file.

6.3 Final Evidence File

The final evidence file will be the central repository for all documents which constitute evidence relevant to sampling and analysis activities as described in this QAPP. The AECOM PM is the custodian of the evidence files and maintains the contents of all the files for the removal action, including all relevant reports, logs, field notes, pictures, subcontractor reports and data reviews in a secured and limited access area and under the custody of the AECOM PM.

At the completion of the project, the final evidence file will be transferred to the custody of the City of Richmond Executive Director. The final evidence file will remain secured at the office of the Executive Director until all submittals for the project have been reviewed and approved by IDEM, and for a minimum of three years past the submittal date of the final report.

7.0 Instrument Calibration and Frequency

7.1 Field Instrument Calibration

Field instrumentation will be limited to a portable photoionization detector (PID) (*e.g.,* MiniRAE 2000 or equivalent). The PID will be used for air monitoring and soil screening. Air monitoring protocols are established in the Site Health and Safety Plan, presented as Attachment D of the RAWP. Soil screening procedures are defined in AECOM SOP 54230-SI-SOP-04, included in **Appendix F-2** of this QAPP. Calibration procedures for the instrument are included in the SOP. All calibration procedures will be documented in the bound field log book. The following information will be recorded in the log book.

- Date/time of calibration;
- Name of operator;
- Reference standard used;
- Temperature at which calibration readings were taken; and
- Calibration readings.

7.2 Laboratory Instrument Calibration

Calibration of laboratory equipment will be based on approved written procedures. Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory analyst. These records will be filed at the location where the work is performed and will be subject to QA/QC audit.

For all instruments, the laboratory maintains in-house spare parts or service contracts with vendors. Laboratory procedures for instrument calibration and frequency will be carried out as detailed in the laboratory Quality Assurance Manual (**Appendix F-1**).

8.0 Analytical Procedures

8.1 Field Analytical Procedures

Field analyses will be conducted only for head space screening of soil samples, in accordance with AECOM SOP 54230-SI-SOP-04, shown in **Appendix F-2**.

8.2 Laboratory Analytical Procedures

Laboratory analyses will be conducted using the methods specified in **Table F-1**. Specific laboratory procedures are documented in the laboratory Quality Assurance Manual provided in **Appendix F-1**.

9.0 Internal Quality Control Checks

9.1 Field Measurements

The Project Manager or Field Team Leader will check the bound logs at the end of work days to ensure that the appropriate field measurements were taken, and that QA/QC results are within acceptance guidelines.

9.2 Analytical Laboratory Measurements

The quality assurance (QA) program and quality control (QC) checks will be used by the laboratory to ensure the production of analytical data of known and documented usable quality. The laboratory has a written QA/QC program that provides rules and guidelines to ensure the reliability and validity of work conducted at the laboratory. Compliance with the QA/QC program is coordinated and monitored by the Laboratory Quality Assurance Officer. The objectives of the laboratory QA/QC program are to:

- Ensure that all procedures are documented, including any changes in administrative and/or technical procedures;
- Ensure that all analytical procedures are conducted according to sound scientific principles and have been validated;
- Monitor the performance of the laboratory by a systematic inspection program and provide for a corrective action as necessary; and
- Ensure that all data are properly recorded and archived.

Internal QC procedures for analytical services will be conducted by the laboratory in accordance with their standard operating procedures and the individual method requirements. The laboratory level of QA/QC will include analyzing calibration verification standards, spikes, control samples, blanks, replicates, and matrix spikes. Internal quality control checks and their frequency will be carried out as detailed in the laboratory Quality Assurance Manual (**Appendix F-1**).

The laboratory will document, in each data package provided, that both initial and ongoing instrument and analytical QC functions have been met. Any samples analyzed in non-conformance with the QC criteria will be reanalyzed by the laboratory. It is expected that sufficient volume of samples will be collected for reanalysis. Method specific quality control measures and frequencies are found in the laboratory Quality Assurance Manual (**Appendix F-1**).

10.0 Data Reduction, Validation and Reporting

10.1 Data Reduction

10.1.1 Procedures for Reduction of Field Data

Field data reduction procedures will be minimal in scope compared with those employed for laboratory data. Field data will be limited to those obtained from portable, direct-read instruments. Direct read data will be transcribed in waterproof ink in bound field log books immediately after measurements are taken. If errors are made, they will be crossed out neatly, initialed and dated by the person keeping the log book, and the correct reading entered in a space adjacent to the original erroneous entry. Any tables based upon these field readings will be checked for transcription errors by the Field Team Leader.

10.1.2 Procedures for Reduction of Laboratory Data

The laboratory will perform in-house analytical data reduction and validation under the direction of the Laboratory QA Coordinator as described in the laboratory Quality Assurance Manual (**Appendix F-1**). The Laboratory QA Coordinator is responsible for assessing data quality and advising of any data that were rated "preliminary" or "unacceptable" or other notations that would caution the data user of possible unreliability. Data reduction, validation, and reporting by the laboratory will be conducted according to the following procedures:

- Raw data produced by the analyst is turned over to the respective area supervisor.
- The operations manager reviews the data for attainment of quality control criteria as outlined in established United States Environmental Protection Agency (US EPA) methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a computerized QA report is generated and sent to the Laboratory QA Coordinator.
- The Laboratory QA Coordinator and Operation Manager will decide whether any sample reanalysis is required.
- Upon acceptance of the preliminary reports by the Laboratory QA Coordinator, final reports will be generated and signed by the Laboratory Project Manager. The laboratory package shall be presented in the same order in which the samples were received.

The laboratory will prepare and retain full analytical and QC documentation. The retained documentation need not be hard (paper) copy, but may be in other storage media (e.g., magnetic tape, compact disc). As needed, the laboratory will supply a hard copy of the retained information. The laboratory will report the data in the same chronological order in which analyses are conducted, along with QC data. Each analytical data package will include the following:

- Cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis;
- Tabulated results of inorganic and organic compounds identified and quantified;
- Analytical results for sample spikes, sample duplicates, and laboratory control samples; and

- Tabulation of instrument detection limits determined in pure water.

For all analyses, surrogate spike recoveries, chromatograms, GC/MS spectra, computer printouts, initial and a continuous calibration verification of standards and blanks, standard procedural blanks, ICP interference check samples, raw data system printouts (or legible photocopies) identifying date of analyses, analyst, and parameters determined, will be retained by the laboratory. These data will be made available upon request.

The assessment of laboratory data will be accomplished by the joint efforts of the Laboratory QA Coordinator and Laboratory Project Manager. The data assessment will be based on the understanding that the sample was properly collected and handled. The laboratory data reviewers will conduct a systematic review of the data for compliance with the established QC criteria based on the spike, duplicate and blank results provided by the laboratory.

An evaluation of data accuracy, precision, and completeness will be performed and presented in the Remediation Completion Report. The data review will identify any out-of-control data points and data omissions and interact with the laboratory to correct data deficiencies. Decisions to repeat sample collection and analyses may be made by the AECOM PM based on the extent of the deficiencies and their importance in the overall context of the project.

10.2 Data Validation

10.2.1 Procedures for Validation of Field Data

Field data validation will be performed by the QA/QC Officer. Validation generally will consist of reviewing the field log book and data sheets for transcription errors, and to confirm compliance with field SOPs. The QA/QC Officer will not otherwise participate in making field measurements or notes.

10.2.2 Procedure for Validation of Laboratory Data

Validation of laboratory data will be performed as outlined in the Laboratory Quality Assurance Manual (**Appendix F-1**) prior to delivery of completed analytical reports to AECOM and/or the City of Richmond. Upon receipt of final laboratory reports, the AECOM QA/QC Officer or his designee will review the data for completeness, and adherence to the analytical scope and specifications as established in the RAWP and QAPP.

10.3 Data Reporting

10.3.1 Field Data Reporting

Field data reporting shall be conducted principally through the transmission of report sheets containing tabulated results of all measurements made in the field, and documentation of all field calibration activities.

10.3.2 Laboratory Data Reporting

Final review by the Laboratory QA Coordinator or the AECOM PM will be performed to determine whether the report meets the project requirements. The required contents of the Case Narrative and Analytical Data packages are listed below.

Case Narrative:

- Project Name/Description;
- Date of Sample collection(s);
- Laboratory Sample Numbers;
- Field Chain-of-Custody;
- Discussion of sample qualifications;
- Discussion of technical problems or other observations which may have created analytical difficulties;
- Discussion of any laboratory quality control checks which failed to meet project criteria; and
- Signature of the laboratory QA Manager.

Analytical Data Package:

- Quality Control Summary;
- Sample Data Package;
- Standards Data;
- Raw Quality Control Data; and
- Miscellaneous.

11.0 Performance and System Audits

Performance and system audits of both field and laboratory activities will be conducted to verify that sampling and analysis are performed in accordance with the procedures established in the RAWP and QAPP. The audits of field and laboratory activities normally include two independent parts: internal and external. For the purposes of the removal action, only internal audits will be addressed.

11.1 Internal Audits of Field Activities

Internal audits of field activities including sampling and field measurements will be conducted by the AECOM QA/QC Officer or his designee. Internal field audits will be conducted periodically on an unannounced basis while field work is underway to verify that all established procedures are being followed.

The purpose of the field audits will be to check performance on sampling protocols, sample preservation, preparation and shipping, record keeping and chain-of-custody, decontamination procedures, maintenance of field notebooks, equipment preventive maintenance, frequency of duplicate sample collection and access control procedures. This information will be audited by direct observation of field sampling, record keeping and sample preparation activities, examination of log books that are kept on site (e.g., instrument logs, chain-of-custody forms, and shipping manifests) and by spot examination of sampler's field notebooks. The results of each audit will be promptly communicated to the AECOM PM in writing.

11.2 Internal Laboratory Audits

Laboratory internal performance and system audits will be conducted as discussed in the Laboratory Quality Assurance Manual (**Appendix F-1**).

12.0 Preventative Maintenance

12.1 Field Instruments

Prior to field use, the instrument will be properly cleaned and calibrated at the AECOM office, in accordance with the manufacturer's specifications. Upon each episode of field use, the instrument will be calibrated in accordance with the manufacturer's specifications. If calibration is not attained in the manner prescribed therein, the instrument will be removed from service for cleaning and/or repair. Back-up instrumentation will be available within a 1-day shipment to avoid lengthy delays due to equipment malfunctions.

12.2 Laboratory Instruments

As part of the QA/QC program, a routine preventive maintenance program is conducted by the laboratory to minimize the occurrence of instrument failure and other system malfunctions. Preventative maintenance procedures that will be carried out by the laboratory are discussed in the Laboratory Quality Assurance Manual (**Appendix F-1**).

13.0 Specific Routine Procedures used to Assess Data Precision, Accuracy and Completeness

Laboratory results will be assessed for compliance with required completeness, accuracy, precision and as described in the following subsections.

13.1 Completeness Assessment

Data completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount expected under normal conditions. For completeness, the data set must contain all analyses verifying precision and accuracy. The data must be reviewed in terms of the stated goals. Completeness is calculated as follows:

- Completeness = (valid data obtained/total data planned) x 100

13.2 Accuracy Assessment

Accuracy of laboratory results will be assessed for compliance with the established QC criteria that are described in Section 2 using the analytical results of methods blanks, reagent/preparation blank, matrix spike/matrix spike duplicate samples, equipment blank, and trip blanks. The percent recovery of matrix spikes will be calculated as follows:

- Percent Recovery = {(Spike Sample Result - Sample Result)/Amount of Spike Added} x 100

13.3 Precision Assessment

Matrix spike duplicates and duplicates are used to assess precision. Analytical precision is expressed as a Relative Percent Difference (RPD) of the difference between the results of two samples for a given parameter divided by the mean of the two results as follows:

- RPD = {(Sample Result - Duplicate Result)/Mean of the Two Results} x 100

14.0 Corrective Action

Corrective action is the process of identifying, recommending, approving and implementing measures to counter unacceptable procedures or out-of-quality-control performance which can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation and data assessment. All corrective action proposed and implemented should be documented in the regular QA reports to management. Corrective action should be implemented only after the approval of the AECOM PM, or his designee, and the AECOM Field Team Leader. If immediate corrective action is required, approvals secured by telephone from the AECOM PM should be documented in an additional memorandum.

All levels of management (including the City of Richmond Executive Director and the IDEM Brownfields PM) must concur with any recommended corrective action which may cause project QA objectives not to be achieved (*e.g*. change in the scope of work, QA requirements, or procedures). Approved changes will be documented as a QAPP addendum.

For noncompliance problems, a formal corrective action program will be determined and implemented at the time the problem is identified. The person who identifies the problem is responsible for notifying the AECOM PM, who will in turn notify the IDEM Brownfields PM. If the problem is analytical in nature, information on these problems will be promptly communicated to the IDEM Brownfields PM. Implementation of corrective action will be confirmed in writing through the same channels.

Any nonconformance with the established quality control procedures in the QAPP or the RAWP will be identified and corrected in accordance with the QAPP. The AECOM PM will issue a nonconformance report for each nonconformance action.

14.1 Field Corrective Action

Corrective action in the field may be required when the sample network is changed (e.g., more or fewer samples, or sampling locations other than those identified in the QAPP), or when sampling procedures require modification due to unexpected conditions.

The need for corrective action and recommendations will be communicated to the AECOM Field Team Leader, who will approve the corrective action and ensure that the corrective action measure(s) has been implemented. Corrective actions will be implemented and documented in a bound field log book. No AECOM personnel will initiate corrective action without prior communication of findings through proper channels. Work may be stopped by the IDEM Brownfields PM if corrective actions are judged to be insufficient.

If corrective action taken supplements the RAWP (i.e., collecting more samples) using existing and approved procedures in this QAPP, the AECOM Field Team Leader will document the corrective action taken. If corrective action taken will result in fewer samples collected, fewer parameters analyzed for, alternate sampling locations, or other changes which might result in non-attainment of QA objectives, then all levels of project management, including the IDEM Brownfields PM, must be advised of the proposed corrective action and must concur in its implementation.

Corrective action recommended as a result of internal field audits will be implemented immediately if data quality may be adversely affected due to use of improper methods, or to the improper use of approved methods. The AECOM QA/QC Officer will identify deficiencies and recommend corrective actions to the AECOM PM, who will notify the City of Richmond Executive Director for approval of the corrective actions. If approved, the AECOM Field Team Leader will ensure that corrective actions are implemented, and will document their implementation. Corrective action will be documented in QA reports to the management.

14.2 Laboratory Corrective Action

Laboratory corrective action is discussed in the Laboratory Quality Assurance Manual (**Appendix F-1**).

15.0 Quality Assurance Reports to Management

Each deliverable report will contain QA sections summarizing data quality information collected during the activities reported. Data accuracy, completeness and precision will be discussed, as well as the results of any performance or system audits. Any corrective actions needed or taken during the task will be discussed. The AECOM PM will be responsible for ensuring that QA sections are included in each deliverable.

Tables

Table F-1
SAMPLING AND ANALYSIS SUMMARY

Sample Type	Sample Matrix	Laboratory Parameters	Analytical Method (EPA SW846)	DQO	Investigative Samples [(2)]	Field QA/QC Samples: Duplicates	Field QA/QC Samples: Equip. Blanks	Field QA/QC Samples: MS/MSD	Trip Blanks [(1)]	Estimated Total
Waste Characterization	Soil [(3)]	TCLP Benzene	8260	III	1 / 1000 tons	0		0		9
Confirmation	Soil	BTEX	8260B	IV	36	4		2		42
		PAHs	8270C	IV	36	4		2		42
		Cyanide, free	SM20 4500-CN-I Modified	IV	36	4		2		42
		Metals	6010	IV	36	4		2		42
		Mercury	7470	IV	36	4		2		42
	QC Blank (water)	BTEX	8260B	IV			4		15	19
		PAHs	8270C	IV			4		0	4
		Cyanide, free	SM20 4500-CN-I Modified	IV			4		0	4
		Metals	6010	IV			4		0	4
		Mercury	7471	IV			4		0	4

Notes:
1 Trip blanks will be analyzed only for BTEX
2 May be revised during implementation; no surface soil samples will be collected from sidewalls bordering gravel, asphalt, or fencing
3 Characterization requirements subject to approval from disposal facility
DQO - Data Quality Objective

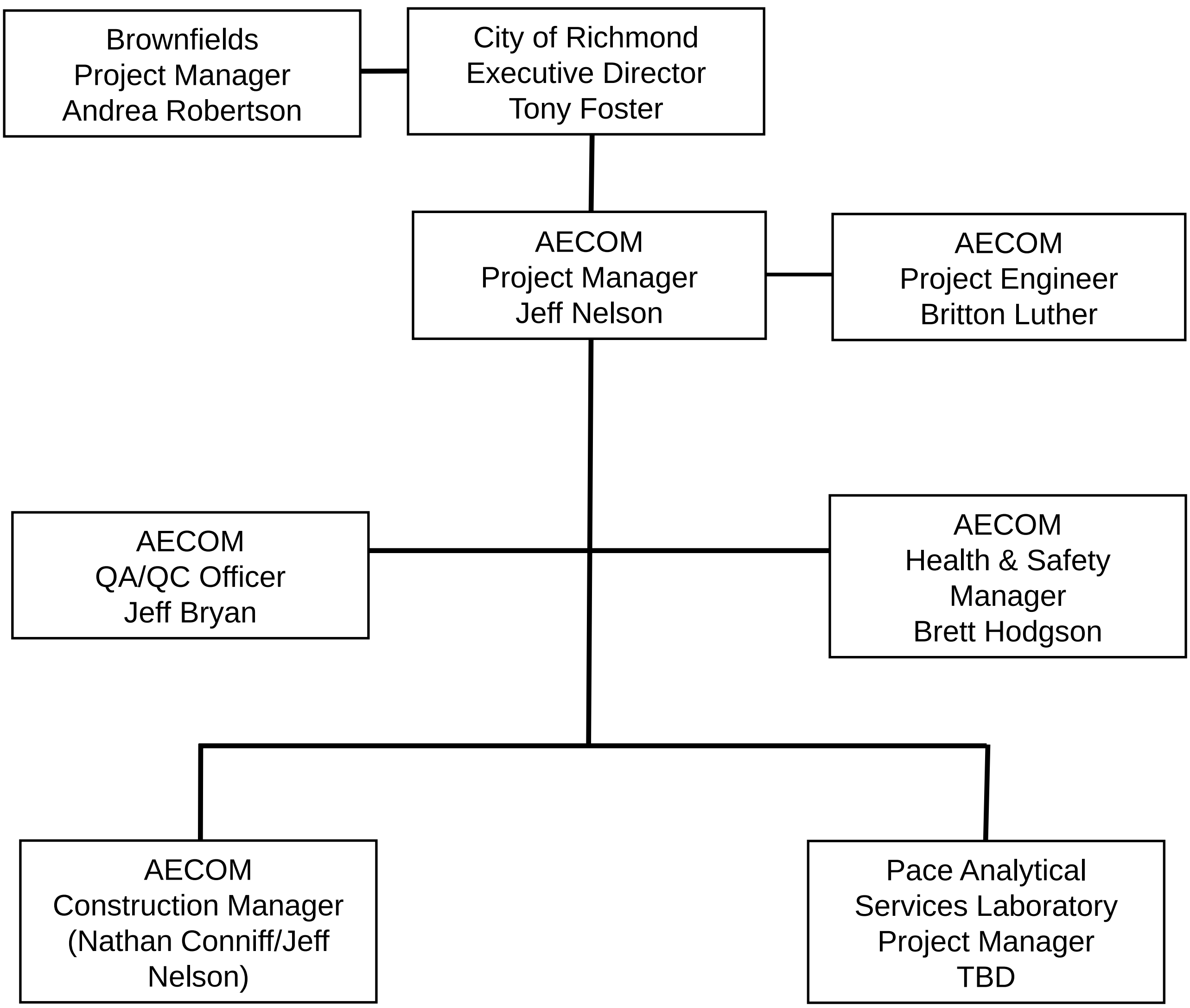
Table F-2
Responsibility for Major Activities

Major Activity	Company/Person Responsible	Location
Sampling	AECOM - Construction Manager/TBD	Onsite
Soil Excavation	AECOM - Construction Manager/TBD	Onsite
Soil & Source Blending	AECOM - Construction Manager/TBD	Onsite
Waste Transportation	TBD	Offsite
Waste Disposal	TBD	Offsite
Analytical Services	Pace Analytical	Indianapolis, IN
Report Preparation	AECOM - Project Manager	Bloomington/Indianapolis, IN

Notes:
TBD – To be determined

Figures

Figure F-1
Project Organization



Appendix F-1

Laboratory Quality Assurance Manual

QUALITY ASSURANCE MANUAL

Quality Assurance/Quality Control
Policies and Procedures

Pace Analytical Services – Indianapolis
7726 Moller Road
Indianapolis, IN 46268
(317)875-5894

CORPORATE APPROVAL

May 14, 2010

Steve A. Vanderboom
President, CEO
1700 Elm Street SE, Suite 200
Minneapolis, MN 55414
(612) 607-1700

Date

May 14, 2010

Bruce Warden
Director of Quality, Safety, and Training
1700 Elm Street SE, Suite 200
Minneapolis, MN 55414
(612) 607-1700

Date

PACE ANALYTICAL SERVICES – INDIANAPOLIS
LOCAL APPROVAL

This document has been approved as the Quality Assurance Manual, effective December 16, 2010, as indicated by the following signatures:

General Manager (317)875-5894	November 23, 2010 Date
Quality Manager (317)875-5894	November 15, 2010 Date
Technical Director (317)875-5894	December 16, 2010 Date

Additional Signatures

Signature	Title	Date
Signature	Title	Date
Signature	Title	Date

Table of Contents

1.0 INTRODUCTION AND ORGANIZATIONAL STRUCTURE

"Working together to protect our environment and improve our health"

Pace Analytical Services Inc. - Mission Statement

1.1 Introduction to PASI

Pace Analytical Services, Inc. (PASI) is a privately held, full-service analytical testing firm operating a nationwide system of laboratories. PASI offers extensive services beyond standard analytical testing, including: bioassay for aquatic toxicity, air toxics, industrial hygiene testing, explosives, high resolution mass spectroscopy (including dioxins, furans and coplanar PCB's), radiochemical analyses, product testing, pharmaceutical testing, field services and mobile laboratory capabilities. PASI has implemented a consistent Quality System in each of its laboratories and service centers. In addition, the company utilizes an advanced data management system that is highly efficient and allows for flexible data reporting. Together, these systems ensure data reliability and superior on-time performance. This document defines the Quality System and QA/QC protocols.

Our goal is to combine our expertise in laboratory operations with customized solutions to meet the specific needs of our customers.

1.2 Statement of Purpose

To meet the business needs of our customers for high quality, cost-effective analytical measurements and services.

1.3 Quality Policy Statement and Goals of the Quality System

The PASI management is committed to maintaining the highest possible standard of service for our customers by following a documented quality system. The overall objective of this quality system is to provide reliable data through adherence to rigorous quality assurance policies and quality control procedures as documented in this Quality Assurance Manual.

All personnel within the PASI network are required to be familiar with all facets of the quality system and implement these policies and procedures in their daily work. This daily focus on quality is applied with initial project planning, continued through all field and laboratory activities, and is ultimately included in the final report generation.

PASI management demonstrates its commitment to quality by providing the resources, including facilities, equipment and personnel to ensure the adherence to these documented policies and procedures and to promote the continuous improvement of the quality system. All PASI personnel comply with all current applicable state, federal, and industry standards (such as the NELAC, NVLAP and ISO 17025 standards).

1.4 Pace Analytical Services Core Values

- **INTEGRITY**
- **VALUE EMPLOYEES**
- **KNOW OUR CUSTOMERS**
- **HONOR COMMITMENTS**
- **FLEXIBLE RESPONSE TO DEMAND**
- **PURSUE OPPORTUNITIES**
- **CONTINUOUSLY IMPROVE**

1.5 Code of Ethics

PASI's fundamental ethical principles are as follows:

- Each PASI employee is responsible for the propriety and consequences of his or her actions.
- Each PASI employee must conduct all aspects of Company business in an ethical and strictly legal manner, and must obey the laws of the United States and of all localities, states and nations where PASI does business or seeks to do business.
- Each PASI employee must reflect the highest standards of honesty, integrity and fairness on behalf of the Company with customers, suppliers, the public, and one another.

Strict adherence by each PASI employee to this Code of Ethics and to the Standards of Conduct is essential to the continued vitality of PASI.

Failure to comply with the Code of Ethics and Standards of Conduct will result in disciplinary action up to and including termination and referral for civil or criminal prosecution where appropriate. An employee will be notified of an infraction and given an opportunity to explain, as prescribed under current disciplinary procedures.

1.6 Standards of Conduct

1.6.1 Data Integrity

The accuracy and integrity of the analytical results produced at PASI are the cornerstones of the company. Lack of data integrity is an assault on our most basic values and puts PASI and its employees at grave financial and legal risk. Therefore, employees are to accurately prepare and maintain all technical records, scientific notebooks, calculations and databases. Employees are prohibited from making false entries or misrepresentations of data (e.g., dates, calculations, results or conclusions).

Managerial staff must make every effort to ensure that personnel are free from any undue pressures that may affect the quality or integrity of their work; including commercial, financial, over-scheduling and working condition pressures.

1.6.2 Confidentiality

PASI employees must not (directly or indirectly) use or disclose confidential or proprietary information except when in connection with their duties at PASI. This is effective over the course of employment and for a period of two years thereafter.

Confidential or proprietary information, belonging to either PASI and/or its customers, includes but is not limited to test results, trade secrets, research and development matters, procedures, methods, processes and standards, company-specific techniques and equipment, marketing and customer information, inventions, materials composition, etc.

1.6.3 Conflict of Interest

PASI employees must avoid situations that might involve a conflict of interest or appear questionable to others. The employee must be careful in two general areas:

- Participation in activities that conflict or appear to conflict with PASI responsibilities.
- Offering or accepting anything that might influence the recipient or cause another person to believe that the recipient may be influenced. This includes bribes, kickbacks or illegal payments.

Employees are not to engage in outside business or economic activity relating to a sale or purchase by the Company. Other questionable activities include service on the Board of Directors of a competing or supplier company, significant ownership in a competing or supplier company, employment for a competing or supplier company or participation in any outside business during the employee's work hours.

1.6.4 Compliance

All employees are required to read, understand and comply with the various components of the standards listed in this document. As confirmation that they understand this responsibility, each employee is required to sign an acknowledgment form (either hardcopy or in electronic database) annually (or as revisions become finalized) that becomes part of the employee's permanent record. Employees will be held accountable for complying with the Quality Systems as summarized in the Quality Assurance Manual.

1.7 Laboratory Organization

The PASI Corporate Office centralizes company-wide accounting, business development, financial management, human resources development, information systems, marketing, quality, safety, and training activities. PASI's Director of Quality is responsible for assisting the development, implementation and monitoring of quality programs for the company. See Attachment IIB for the Corporate Organizational structure.

Each laboratory within the system operates with local management, but all share common systems and receive support from the Corporate Office.

A General Manager (GM) supervises each regional laboratory. Some operations may have an Assistant General Manager (AGM) in situations where the General Manager is responsible for multiple laboratory facilities and is not necessarily in the facility on a regular basis. Quality Managers (QM) at each lab report directly to their General Manager (or Assistant General Manager) but receive guidance and direction from the Director of Quality.

The General Manager bears the responsibility for the laboratory operations and serves as the final, local authority in all matters. In the absence of the General Manager (and an Assistant General Manager), the Quality Manager serves as the next in command. He or she assumes the responsibilities of the GM until the GM is available to resume the duties of their position. In the absence of the GM and QM, management responsibility of the laboratory is passed to the Technical Director – provided such a position is identified – and then to the most senior department manager until the return of the GM or QM. The most senior department manager in charge may include the Client Services Manager or the Administrative Business Manager at the discretion of the General Manager.

A Technical Director who is absent for a period of time exceeding 15 consecutive calendar days shall designate another full-time staff member meeting the qualifications of the technical director to temporarily perform this function. The laboratory General Manager or Quality Manager has the authority to make this designation in the event the existing Technical Director is unable to do so. If this absence exceeds 35 consecutive calendar days, the primary accrediting authority shall be notified in writing.

The Quality Manager has the responsibility and authority to ensure the Quality System is implemented and followed at all times. In circumstances where a laboratory is not meeting the established level of quality or following the policies set forth in this Quality Assurance Manual, the Quality Manager has the authority to halt laboratory operations should he or she deem such an action necessary. The QM will immediately communicate the halting of operations to the GM and keep him or her posted on the progress of corrective actions. In the event the GM and QM are not in agreement as to the need for the suspension, the Chief Operating Officer and Director of Quality will be called in to mediate the situation.

Under the direction of the General Manager, the technical staff of the laboratory is generally organized into the following functional groups:

- Organic Sample Preparation
- Wet Chemistry Analysis
- Metals Analysis
- Volatiles Analysis
- Semi-volatiles Analysis
- Radiochemical Analysis
- Microbiology

Appropriate support groups are present in each laboratory. The actual organizational structure for PASI – Indianapolis is listed in Attachment IIA. In the event of a change in General Manager, Quality Manager or Technical Director(s), the laboratory will notify its accrediting authorities and revise the organizational chart in the Quality Assurance Manual (QAM) within 30 days. For changes in Department Managers or Supervisors or other laboratory personnel, no notifications will be sent to the laboratory's accrediting agencies; changes to the organizational chart will be updated during or prior to the annual review process. Changes or additions in these key personnel will also be noted by the additional signatures on the QAM Local Approval page. In any case, the QAM will remain in effect until the next scheduled revision.

1.8 Laboratory Job Descriptions

1.8.1 Senior General Manager

- Oversees all functions of all the operations within their designated region,
- Oversees the development of local General Managers within their designated region,
- Oversees and authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation,
- Oversees the preparation of budgets and staffing plans for all operations within their designated region, and
- Ensures compliance with all applicable state, federal and industry standards.

1.8.2 General Manager (local lab)

- Oversees all functions of the operations,
- Authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation,
- Prepares budgets and staffing plans,
- Monitors the Quality Systems of the laboratory and advises the Quality Manager accordingly, and
- Ensures compliance with all applicable state, federal and industry standards.

1.8.3 Assistant General Manager / Operations Manager

- In the absence of the GM, performs all duties as listed above for the General Manager,
- Oversees the daily production and quality activities of all departments,
- Manages all departments and works with staff to ensure department objectives are met,
- Works with all departments to ensure capacity and customer expectations are accurately understood and met,
- Works with General Manager to prepare appropriate budget and staffing plans for all departments,
- Responsible for prioritizing personnel and production activities within all departments, and
- Performs formal and informal performance reviews of departmental staff.

1.8.4. Quality Manager

- Oversees the laboratory Quality Systems while functioning independently from laboratory operations. Reports directly to the General Manager,
- Monitors Quality Assurance policies and Quality Control procedures to ensure that the laboratory achieves established standards of quality,
- Maintains records of quality control data and evaluates data quality,

- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives,
- Reviews and maintains records of proficiency testing results,
- Maintains the document control system,
- Assists in development and implementation of appropriate training programs,
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements,
- Maintains certifications from federal and state programs,
- Ensures compliance with all applicable state, federal and industry standards, and
- Maintains the laboratory training records, including those in the Learning Management System (LMS).

1.8.5 Technical Director

- Monitors the standards of performance in quality assurance and quality control data,
- Monitors the validity of analyses performed and data generated,
- Reviews tenders, contracts and QAPPs to ensure the laboratory can meet the data quality objectives for any given project,
- Serves as the general manager of the laboratory in the absence of the GM, AGM and QM, and
- Provides technical guidance in the review, development and validation of new methodologies.

1.8.6 Administrative Business Manager

- Responsible for financial and administrative management for the entire facility,
- Provides input relative to tactical and strategic planning activities,
- Organizes financial information so that the facility is run as a fiscally responsible business,
- Works with staff to confirm that appropriate processes are put in place to track revenues and expenses,
- Provide ongoing financial information to the General Manager and the management team so they can better manage their business,
- Utilizes historical information and trends to accurately forecast future financial positions,
- Works with management to ensure that key measurements (mileposts) are put in place to be utilized for trend analysis—this will include personnel and supply expenses, and key revenue and expense ratios,
- Works with General Manager to develop accurate budget and track on an ongoing basis,
- Works with entire management team to submit complete and justified capital budget requests and to balance requests across departments, and
- Works with project management team and administrative support staff to ensure timely and accurate invoicing.

1.8.7 Client Services Manager

- Oversees all the day to day activities of the Client Services Department which includes Project Management and, possibly, Sample Control,
- Responsible for staffing and all personnel management related issues for Client Services,
- Serves as the primary senior consultant to customers on all project related issues such as set up, initiation, execution and closure, and
- Performs or is capable of performing all duties listed for that of Project Manager.

1.8.8 Project Manager

- Coordinates daily activities including taking orders, reporting data and analytical results,
- Serves as the primary technical and administrative liaison between customers and PASI,
- Communicates with operations staff to update and set project priorities,
- Provides results to customers in the requested format (verbal, hardcopy, electronic, etc.),
- Works with customers, laboratory staff, and other appropriate PASI staff to develop project statements of work or resolve problems of data quality,
- Responsible for solicitation of work requests, assisting with proposal preparation and project initiation with customers and maintain customer records,
- Mediation of project schedules and scope of work through communication with internal resources and management,
- Responsible for preparing routine and non-routine quotations, reports and technical papers,
- Interfaces between customers and management personnel to achieve customer satisfaction,
- Manages large-scale complex projects,
- Supervises less experienced project managers and provide guidance on management of complex projects,
- Arranges bottle orders and shipment of sample kits to customers,
- Enters the sample information into the Laboratory Information Management System (LIMS) for tracking and reporting, and
- Verifies login information relative to project requirements and field sample Chains-of-Custody.

1.8.9 Project Coordinator

- Responsible for preparation of project specifications and provides technical/project support,
- Coordinates project needs with other department sections and assists with proposal preparation,
- Prepares routine proposals and invoicing,
- May enter the sample information into the Laboratory Information Management System (LIMS) for tracking and reporting,
- Responsible for scanning, copying, assembling and binding final reports, and

- Other duties include filing, maintaining forms, process outgoing mail, maintaining training database and data entry.

1.8.10 Department Manager/Supervisor

- Oversees the day-to-day production and quality activities of their assigned department and personnel,
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied,
- Assesses data quality and takes corrective action when necessary,
- Approves and releases technical and data management reports, and
- Ensures compliance with all applicable state, federal and industry standards, and
- Trains analysts in laboratory operations and analytical procedures.

1.8.11 Group Supervisor/Leader

- Trains analysts in laboratory operations and analytical procedures,
- Organizes and schedules analyses with consideration for sample holding times,
- Implements data verification procedures by assigning data verification duties to appropriate personnel,
- Evaluates instrument performance and supervises instrument calibration and preventive maintenance programs, and
- Reports non-compliance situations to laboratory management including the Quality Manager.

1.8.12 Laboratory Analyst

- Performs detailed preparation and analysis of samples according to published methods and laboratory procedures,
- Processes and evaluates raw data obtained from preparation and analysis steps,
- Generates final results from raw data, performing primary review against method criteria,
- Monitors quality control data associated with analysis and preparation. This includes examination of raw data such as chromatograms as well as an inspection of reduced data, calibration curves, and laboratory notebooks,
- Reports data in LIMS, authorizing for release pending secondary approval,
- Conducts routine and non-routine maintenance of equipment as required, and
- Performs or is capable of performing all duties associated with that of Laboratory Technician.

1.8.13 Laboratory Technician

- Prepares standards and reagents according to published methods or in house procedures,
- Performs preparation and analytical steps for basic laboratory methods,
- Works under the direction of a Laboratory Analyst on complex methodologies,
- Assists Laboratory Analysts on preparation, analytical or data reduction steps for complex methodologies, and

- Monitors quality control data as required or directed. This includes examination of raw data such as chromatograms as well as an inspection of reduced data, calibration curves, and laboratory notebooks.

1.8.14 Sample Management Personnel

- Signs for incoming samples and verifies the data entered on the Chain-of-Custody forms,
- Stages samples according to EPA requirements,
- Assists Project Managers and Coordinators in filling bottle orders and sample shipments, and
- May perform sample disposal duties as directed.

1.8.15 Systems Administrator or Systems Manager

- Assists with the creation and maintenance of electronic data deliverables (EDDs),
- Coordinates the installation and use of all hardware, software and operating systems,
- Performs troubleshooting on all aforementioned systems,
- Trains new and existing users on systems and system upgrades,
- Maintains all system security passwords, and
- Maintains the electronic backups of all computer systems.

1.8.16 Safety/Chemical Hygiene Officer

- Maintains the laboratory Chemical Hygiene Plan.
- Plans and implements safety policies and procedures.
- Maintains safety records.
- Organizes and/or performs safety training.
- Performs safety inspections and provides corrective/preventative actions.
- Assists personnel with safety issues (e.g. personal protective equipment).

1.8.17 Hazardous Waste Coordinator (or otherwise named)

- Evaluates waste streams and helps to select appropriate waste transportation and disposal companies.
- Maintains complete records of waste disposal including waste manifests and state reports.
- Assists in training personnel on waste-related issues such as waste handling and storage, waste container labeling, proper satellite accumulation, secondary containment, etc.
- Conducts or ensures the performance of regular inspection of the waste storage areas of the lab.

1.9 Training and Orientation

Each new employee receives a five part orientation: human resources, ethics and data integrity, safety, Quality Systems, and departmental.

The human resources orientation includes benefits, salary, and company policies. All records are stored with Human Resources.

The ethics and data integrity training covers the obligations of each employee to ensure the defensibility of laboratory data. Employees are provided with general policies related to ethics in the laboratory and specific examples of improper practices that are unacceptable in any PASI facility. The employee is trained to make the right decisions with regards to laboratory practices and where to go for answers in circumstances where they may be unclear as to the correct protocol.

The safety orientation includes an in-depth review of the PASI Chemical Hygiene Plan/Safety Plan, which are consistent with the requirements of OSHA's Hazard Communication Program (29 CFR 1910.1200) and other pertinent regulations.

The Quality Systems orientation provides the new employee with information through an introduction to the Quality Assurance Manual and SOPs, acceptable record keeping practices, and the individual's responsibility to data quality. Quality Systems training is reinforced with the new employee as specific topics are covered during the departmental or analytical method training. Quality Systems training will address policies and practices that ensure the quality and defensibility of the analytical data. These topics include but are not limited to traceability of measurements, method calibration, calibration verification, accuracy, precision and uncertainty of measurements, corrective actions, documentation and root cause analysis.

The new employee's Department Supervisor provides the employee with a basic understanding of the role of the laboratory within the structure of PASI and the basic elements of that individual's position.

Supervised training uses the following techniques:

- Hands-on training
- Training checklists/worksheets (e.g. from LMS new hire workbooks)
- Lectures and training sessions
- Method-specific training
- Conferences and seminars
- Short courses
- Specialized training by instrument manufacturers
- Proficiency testing programs.
- On-line courses

Department Managers or Group Supervisors/Leaders are responsible for providing documentation of training and proficiency for each employee under their supervision. The employee's training file indicates what procedures an analyst or a technician is capable of performing, either independently or with supervision. The files also include documentation of continuing capability (see Section 3.4 for details on Demonstration of Capability requirements). Training documentation files for each person are maintained by the Quality Office either in hardcopy format or within the Learning Management System (LMS).

All procedures and training records are maintained and available for review during laboratory audits. These procedures are reviewed/updated periodically by lab management. Additional information can be found in SOP S-ALL-Q-020 ***Training Procedures*** or its equivalent revision or replacement.

1.10 Laboratory Safety

It is the policy of PASI to make safety and health an integral part of daily operations and to ensure that all employees are provided with safe working conditions, personal protective equipment, and requisite training to do their work without injury. Each employee is responsible for his/her own safety by complying with established company rules and procedures. These rules and procedures as well as a more detailed description of the employees' responsibilities are contained in the corporate Safety Manual and Chemical Hygiene Plan.

1.11 Security and Confidentiality

Security is maintained by controlled access to laboratory buildings. Exterior doors to laboratory buildings remain either locked or continuously monitored by PASI staff. Keyless door-lock combinations (and computer access codes/logins) are changed when necessary. Posted signs direct visitors to the reception office and mark all other areas as off limits to unauthorized personnel. All visitors to the facility must sign the Visitor's Logbook maintained by the receptionist. A staff member will accompany them during the duration of their stay on the premises unless the GM, QM or TD specify otherwise. In this instance, the staff member will escort the visitor back to the reception area at the end of his/her visit where he/she signs out. The last staff member to leave their department for the day should ensure that all outside access points to that area are secure.

Access to designated laboratory sample storage locations is limited to authorized personnel only. Provisions for lock and key access are provided. No samples are to be removed without proper authorization. If requested by customer or contract, samples are not to be removed from secure storage areas without filling out the associated internal Chain-of-Custody records.

Standard business practices of confidentiality are applied to all documents and information regarding customer analyses. Specific protocols for handling confidential documents are described in PASI SOPs. Additional protocols for internal identification of samples and data by number only are implemented as required under contract-specific Quality Assurance Project Plans (QAPPs).

All information pertaining to a particular customer, including national security concerns will remain confidential. Data will be released to outside agencies only with written authorization from the customer or where federal or state law requires the company to do so (i.e. federal or state subpoena).

2.0 SAMPLE CUSTODY

2.1 Sampling Support

Each individual PASI laboratory provides shipping containers, sample containers (including applicable chemical preservatives), custody documents, and field quality control samples (e.g., trip blanks) to support field-sampling events. Guidelines for sample container types, preservatives, and holding times for a variety of methods are listed in Attachment VIII. Note that all analyses listed are not necessarily performed at all PASI laboratories and there may be additional laboratory analyses performed that are not included in these tables. PASI – *Indianapolis* may provide pick-up and delivery services to their customers when needed.

2.2 Field Services

Pace Analytical has a large Field Services Division which is based in their Minneapolis facility as well as limited field service capabilities in some of the other facilities. Field Services provides comprehensive nationwide service offerings including:

- Stack Testing
- Ambient Air
- CEM Certification Testing
- Air Quality Monitoring
- Onsite Analytical Services- FTIR and GC
- Real-time Process Diagnostic/Optimization Testing
- Wastewater, Groundwater and Drinking Water Monitoring
- Stormwater and Surface Water Monitoring
- Soil and Waste Sampling
- Mobile Laboratory Services

Field Services operates under the PASI Corporate Quality System, with applicable and necessary provisions to address the activities, methods, and goals specific to Field Services for a unit specific Quality Program. All procedures and methods used by Field Services are documented in Standard Operating Procedures and Procedure Manuals.

2.3 Project Initiation

Prior to accepting new work, the laboratory reviews performance capability. The laboratory establishes that sufficient resources such as personnel, equipment capacity, analytical method capability are available to complete the required work. The customer needs and data quality objectives are defined and appropriate environmental test methods are assured to meet customer's requirements by project managers or sales representative. Project Managers review laboratory certifications. Members of the management staff review current instrument capacity, personnel availability and training, analytical procedures capability and projected sample load. Management then informs the sales and client services personnel whether or not the laboratory can accept the new project via written correspondence, email, and/or daily operations meetings.

The laboratory maintains records of all such reviews, including discussions with customers. Routine analytical project documentation of quotes, notes, dates, initials and/or recordings is maintained in a project folder by project management. Conditions for new and more complex contracts are determined by the General Managers and sales representatives. Quality Management is consulted on technical requirements and operations staff provides input on volume capacities. Evidence of these reviews is maintained in the form of awarded Request for Proposals (RFPs), signed quotes or contracts, and a Customer Relationship Management (CRM) database. If a review identifies a potential mismatch between customer requirements and laboratory capabilities and/or capacities, Pace will specify its level of commitment by listing these exceptions to the requirements within the RFP, quote or contract.

Additional information regarding specific procedures for reviewing new work requests can be found in SOP S-ALL-C-006 ***Review of Analytical Requests*** or its equivalent revision or replacement.

2.4 Chain-Of-Custody

A chain-of-custody (COC) (see Attachment VII) document provides the legal documentation of samples from time of collection to completion of analysis. Importance is stressed on completeness of COCs. PASI has implemented Standard Operating Procedures to ensure that sample custody traceability and responsibility objectives are achieved for every project.

Field personnel or client representatives complete a chain-of-custody form for all samples. Samples are received by the laboratory accompanied by these forms.

If sample shipments are not accompanied by the correct documentation, the Sample Receiving department notifies a Project Manager. The Project Manager then obtains the correct documentation/information from the customer in order for analysis of samples to proceed.

The sampler is responsible for providing the following information on the chain-of-custody form:

- Customer project name
- Project location or number
- Field sample number/identification
- Date and time sampled
- Sample type (matrix)
- Preservative
- Requested analyses
- Sampler signature
- Relinquishing signature
- Date and time relinquished
- Sampler remarks (if applicable)
- Custody Seal Number (if applicable)
- Regulatory Program Designation
- The state where the samples were collected to ensure all applicable state requirements are met
- Turnaround time requested
- Purchase order number

The record is filled out completely and legibly with indelible ink. Errors are corrected by drawing a single line through the initial entry and initialing and dating the change. All transfers of samples are recorded on the chain-of-custody in the “relinquished” and “received by” sections. All information except signatures is printed.

Additional information can be found in SOT-ALL-C-001 ***Sample Management*** or its equivalent revision or replacement.

2.5 Sample Acceptance Policy

In accordance with regulatory guidelines, PASI complies with the following sample acceptance policy for all samples received.

If the samples do not meet the sample receipt acceptance criteria outlined below, the laboratory is required to document all non-compliances, contact the customer, and either reject the samples or fully document any decisions to proceed with analyses of samples which do not meet the criteria. Where applicable, results reported from samples not meeting these criteria are appropriately qualified on the final report.

All samples must:

- Have unique customer identification that are clearly marked with durable waterproof labels on the sample containers and that match the chain of custody.
- Have clear documentation on the chain of custody related to the location of the sampling site with the time and date of sample collection.
- Have the sampler’s name and signature
- Have the requested analyses clearly marked
- Have clear documentation of any special analysis requirements (data deliverables, etc.);
- Be in appropriate sample containers with clear documentation of the preservatives used.
- Be correctly preserved unless method allows for laboratory preservation.
- Be received within holding time. Any samples with hold times that are exceeded will not be processed without prior customer permission.
- Have sufficient sample volume to proceed with the analytical testing. If insufficient sample volume is received, analysis will not proceed without customer approval.
- Be received within appropriate temperature ranges - not frozen but ≤6°C (See Note 1), unless program requirements or customer contractual obligations mandate otherwise (see Note 2). The cooler temperature is recorded directly on the COC and the SCUR. Samples that are delivered to the lab immediately after collection are considered acceptable if there is evidence that the chilling process has been started, for example by the arrival of the samples on ice. If samples arrive that are not compliant with these temperature requirements, the customer will be notified. The analysis will NOT proceed unless otherwise directed by the customer. If less than 72 hours remain in the hold time for the analysis, the analysis may be started while the customer is contacted to avoid exceeding the hold time. Data will be appropriately qualified on the final report.

  Note 1: Temperature will be determined and recorded based on the precision of the measuring device. For example, temperatures obtained from a thermometer graduated to 0.1°C will be determined and recorded to ±0.1°C. Measurements obtained from a thermometer graduated to 0.5°C will be determined to ±0.5°C. Measurements read at the specified precision are not to be rounded down to meet the ≤6°C limit (i.e. 6.2°C rounded and recorded as 6°C).

Note 2: Some microbiology methods allow sample receipt temperatures of up to 10°C. Consult the specific method for microbiology samples received above 6°C prior to initiating corrective action for out of temperature preservation conditions.

Note 3: Biological Tissue Samples must be received frozen at ≤0°C.

Upon sample receipt, the following items are also checked and recorded:

- Presence of custody seals or tapes on the shipping containers
- Sample condition: Intact, broken/leaking
- Sample holding time
- Sample pH when required
- Appropriate containers

Samples for drinking water analysis that are improperly preserved, or are received past holding time, are rejected at the time of receipt, with the exception of VOA samples that are tested for pH post-analysis.

Additional information can be found in SOT-ALL-C-001 ***Sample Management*** or its equivalent revision or replacement.

2.6 Sample Log-in

After sample inspection, all sample information on the chain-of-custody is entered into the Laboratory Information Management System (LIMS).

This permanent record documents receipt of all sample containers including:

- Customer name and contact
- Customer number
- Pace Analytical project number
- Pace Analytical Project Manager
- Sample descriptions
- Due dates
- List of analyses requested
- Date and time of lab receipt
- Field ID code
- Date and time of collection
- Any comments resulting from inspection for sample rejection

All samples received are logged into the LIMS system within one working day of receipt. Sample login may be delayed due to customer clarification of analysis needed, corrective actions for sample receipt non-conformance, or other unusual circumstances. If the time collected for any sample is unspecified and Pace is unable to obtain this information from the customer, the laboratory will use 08:00 as the time sampled. All hold times will be based on this sampling time and qualified accordingly if exceeded.

The Laboratory Information Management System (LIMS) automatically generates a unique identification number for each sample created in the system. The LIMS sample number follows the general convention of XXXXXX (insert LIMS sample numbering convention). This unique identification number is placed on the sample container as a durable label and becomes the link between the laboratory's sample management system and the customer's field identification; it will be a permanent reference number for all future interactions.

Current region codes are noted below. More may be added without updating this document.

10 = Minnesota	35 = Florida
92 = Asheville and Charlotte	20 = Gulf Coast
60 = Kansas	30 = Pittsburgh
50 = Indianapolis	40 = Green Bay
3038 = Pittsburgh Radiological	17 = Pace Life Sciences
25 = Seattle	

Sample labels are printed from the LIMS system and affixed to each sample container.

Samples with hold times that are near expiration date/time may be sent directly to the laboratory for analysis at the discretion of the Project Manager and/or General Manager.

Additional information can be found in SOT-ALL-C-001 ***Sample Management*** or its equivalent revision or replacement.

2.7 Sample Storage

2.7.1 Storage Conditions

Samples are stored away from all standards, reagents, or other potential sources of contamination. Samples are stored in a manner that prevents cross-contamination (e.g. volatile samples are stored separate from other samples). All sample fractions, extracts, leachates and other sample preparation products are stored in the same manner as actual samples or as specified by the analytical method

2.7.2 Temperature Monitoring

Samples are taken to the appropriate storage location immediately after sample receipt and check-in procedures are completed. All sample storage areas are located in limited access areas and are monitored to ensure sample integrity.

The temperature of each refrigerated storage area is maintained at $\leq 6^{\circ}$C unless state or program requirements differ. The temperature of each freezer storage area is maintained at < - 10^{o}C unless state or program requirements differ. The temperature of each storage area is monitored and recorded each workday. If the temperature falls outside the acceptable limits, the following corrective actions are taken and appropriately documented:

- The temperature is rechecked after two hours to verify temperature exceedance. Corrective action is initiated if necessary.
- The Quality Manager and/or laboratory management are notified if the problem persists.
- The samples are relocated to a proper environment if the temperature cannot be maintained after corrective actions are implemented.
- If the samples have been compromised, the affected customers are notified.
- If the samples have been compromised, documentation is provided on analytical report.

2.7.3 Hazardous Materials

Pure product or potentially heavily contaminated samples may be tagged as "hazardous" or "lab pack" and are stored separately from other samples.

2.7.4 Foreign/Quarantined Soils

Depending on the soil disposal practices of the laboratory, foreign soils and soils from USDA regulated areas are segregated. The USDA requires these samples to be incinerated or sterilized by an approved treatment procedure.

Additional information on sample storage can be found in SOT-ALL-C-001 ***Sample Management*** or its equivalent revision or replacement and in SOT-ALL-S-002 ***Waste Handling and Management***.

2.8 Sample Protection

PASI laboratory facilities are operated under controlled access to ensure sample and data integrity. Visitors must register at the front desk and be properly escorted.

Samples are removed from storage areas by designated personnel and returned to the storage areas, if necessary, immediately after the required sample quantity has been taken.

Upon customer request, additional and more rigorous chain-of-custody protocols for samples and data can be implemented. For example, some projects may require complete documentation of sample custody within the secure laboratory.

Additional information can be found in SOT-ALL-C-001 ***Sample Management*** or its equivalent revision or replacement.

2.9 Subcontracting Analytical Services

Every effort is made to perform chemical analyses for PASI customers within the laboratory that receives the samples. When subcontracting to a laboratory other than the receiving laboratory becomes necessary, a preliminary verbal communication with an appropriate laboratory is undertaken. Customers are notified in writing of the lab's intention to subcontract any portion of the testing to another laboratory. Work performed under specific protocols may involve special considerations.

Prior to subcontracting samples to a laboratory outside Pace Analytical, the potential sub-contract laboratory will be pre-qualified by verifying that the subcontractor meets the following criteria:

- All certifications required for the proposed subcontract are in effect,
- Sufficient professional liability and other required insurance coverage is in effect, and
- Is not involved in legal action by any federal, state, or local government agency for data integrity issues and has not been convicted in such investigation at any time during the past 5 years.

The contact and preliminary arrangements are made between the PASI Project Manager and the appropriate subcontract laboratory personnel. The specific terms of the subcontract laboratory agreement include:

- Method of analysis
- Number and type of samples expected
- Project specific QA/QC requirements
- Deliverables required
- Laboratory certification requirement
- Price per analysis
- Turn-around time requirements

Chain-of-custody forms are generated for samples requiring subcontracting to other laboratories. Sample receiving personnel re-package the samples for shipment, create a transfer chain-of-custody form and record the following information:

- Pace Analytical Laboratory Number
- Matrix
- Requested analysis
- Special instructions (quick turn-around, required detection or reporting limits, unusual information known about the samples or analytical procedure).
- Signature in "Relinquished By"

All subcontracted sample data reports are sent to the PASI Project Manager.

Any Pace Analytical work sent to other labs within the PASI network is handled as subcontracted work or inter-regional work and all final reports are labeled clearly with the name of the laboratory performing the work. PASI will not be responsible for analytical data if the subcontract laboratory was designated by the customer.

Additional information can be found in SOT-ALL-C-003 ***Subcontracting Samples*** or its equivalent revision or replacement.

2.10 Sample Retention and Disposal

Samples and sample by-products must be retained by the laboratory for a period of time necessary to protect the integrity of the sample or sample by-product and to protect the interests of the laboratory and the customer.

Unused portions of samples are retained by each laboratory based on program or customer requirements for sample retention and storage. The sample retention time is a minimum of 45 days from receipt of the samples. Samples requiring storage beyond this time due to special requests or contractual obligations will not be stored under temperature controlled conditions unless the laboratory has sufficient capacity and their presence does not compromise the integrity of other samples.

After this period expires, non-hazardous samples are properly disposed of as non-hazardous waste.
The preferred method for disposition of hazardous samples is to return the excess sample to the customer. If it is not feasible to return samples, or the customer requires PASI to dispose of excess samples, PASI will arrange for proper disposal by an approved contractor.

Additional information can be found in SOT-ALL-S-002 ***Waste Handling and Management*** and SOT-ALL-C-001 ***Sample Management*** or their equivalent revisions or replacements.

3.0 ANALYTICAL CAPABILITIES

3.1 Analytical Method Sources

PASI laboratories are capable of analyzing a full range of environmental samples from a variety of matrices, including air, surface water, wastewater, groundwater, soil, sediment, biota, and other waste products. The latest valid editions of methodologies are applied from regulatory and professional sources including EPA, ASTM, USGS, NIOSH, A2LA, A-Class, NVLAP and State Agencies. Section 11 is a representative listing of general analytical protocol references. PASI discloses in writing to its customers and regulatory agencies any instances in which modified methods are being used in the analysis of samples.

In the event of a customer-specific need, instrumentation constraint or regulatory requirement, PASI laboratories reserve the right to use valid versions of methods that may not be the most recent edition available.

3.2 Analytical Method Documentation

The primary form of documentation of analytical methods is the Standard Operating Procedure (SOP). SOPs contain pertinent information as to what steps are required by an analyst to successfully perform a procedure. The required contents for the SOPs are specified in the company-wide SOP for Preparation of SOPs (S-ALL-Q-001).

The SOPs may be supplemented by other training materials that further detail how methods are specifically performed. This training material will undergo periodic, documented review along with the other Quality System documentation.

3.3 Analytical Method Validation

In some situations, PASI develops and validates methodologies that may be more applicable to a specific problem or objective. When non-standard methods (e.g. methods other than EPA, NIOSH, ASTM, AOAC, etc.) are required for specific projects or analytes of interest, or when the laboratory develops a method, or modifies a standard method, the laboratory validates the method prior to applying it to customer samples. Method validity is established by meeting criteria for precision and accuracy as established by the data quality objectives specified by the end user of the data. The laboratory records the validation procedure, the results obtained and a statement as to the usability of the method. The minimum requirements for method validation include determination of the limit of detection and limit of quantitation, evaluation of precision and bias, and evaluation of selectivity of each analyte of interest.

3.4 Demonstration of Capability (DOC)

Analysts complete an initial demonstration of capability (IDOC) study prior to performing a method or when there is a change in instrument type, personnel or test method (when a defined 'work cell' is in operation, the entire work cell must meet the criteria). The mean recovery and standard deviation of each analyte, taken from 4 replicates of a quality control standard is calculated and compared to method criteria (if available) or established lab criteria for evaluation of acceptance. Each laboratory maintains copies of all demonstrations of capability and corresponding raw data for future reference and must document the acceptance criteria prior to the analysis of the DOC. Demonstrations of capability are verified on an annual basis.

For Continuing Demonstrations of Capability, the laboratories may use Performance Testing (PT) samples in lieu of the 4 replicate approach listed above. For methods or procedures that do not lend themselves to the "4 replicate" approach, the demonstration of capability requirements will be specified in Section 13 – Method Performance of the applicable SOP.

Additional information can be found in SOP S-ALL-Q-020 ***Training Procedures*** or its equivalent revision or replacement.

3.5 Regulatory and Method Compliance

PASI understands that expectations of our customers commonly include the assumption that laboratory data will satisfy specific regulatory requirements. Therefore PASI attempts to ascertain, prior to beginning a project, what applicable regulatory jurisdiction, agency, or protocols apply to that project. This information is also required on the Chain-of-Custody submitted with samples.

PASI makes every effort to detect regulatory or project plan inconsistencies, based upon information from the customer, and communicate them immediately to the customer in order to aid in the decision-making process. PASI will not be liable if the customer chooses not to follow PASI recommendations.

It is PASI policy to disclose in a forthright manner any detected noncompliance affecting the usability of data produced by our laboratories. The laboratory will notify customers within 30 days of fully characterizing the nature of the nonconformance, the scope of the nonconformance and the impact it may have on data usability.

4.0 QUALITY CONTROL PROCEDURES

4.1 Data Integrity System

The data integrity system at PASI provides assurances to management that a highly ethical approach is being applied to all planning, training and implementation of methods. Data integrity is crucial to the success of our company and Pace Analytical is committed to providing a culture of quality throughout the organization. To accomplish this goal, PASI has implemented a data integrity system that encompasses the following four requirements:

1. A data integrity training program: standardized training is given to each new employee and a yearly refresher is presented to all employees. Key topics within this training include:
   a. Need for honesty in analytical reporting
   b. Process for reporting data integrity issues
   c. Specific examples of unethical behavior and improper practices
   d. Documentation of non-conforming data that is still useful to the data user
   e. Consequences and punishments for unethical behavior
   f. Examples of monitoring devices used by management to review data and systems
2. Signed data integrity documentation for all employees: this includes a written quiz following the Ethics training session and written agreement to abide by the Code of Ethics and Standards of Conduct explained in the employee manual.
3. In-depth, periodic monitoring of data integrity: including peer data review and validation, internal data audits, proficiency testing studies, etc.
4. Documentation of any review or investigation into possible data integrity infractions. This documentation, including any disciplinary actions involved, corrective actions taken, and notifications to customers must be available for review for lab assessors and must be retained for a minimum of five years.

PASI management makes every effort to ensure that personnel are free from any undue pressures that affect the quality of their work including commercial, financial, over-scheduling, and working condition pressures.

Corporate management also provides all PASI facilities a mechanism for confidential reporting of data integrity issues that ensures confidentiality and a receptive environment in which all employees are comfortable discussing items of ethical concern. The anonymous message line is monitored by the Corporate Director of Quality who will ensure that all concerns are evaluated and, where necessary, brought to the attention of executive management and investigated. **The message line voice mail box number is available in the Pace Employee Handbook.**

4.2 Method Blank

A method blank is used to evaluate contamination in the preparation/analysis system. The method blank is processed through all preparation and analytical steps with its associated samples.

A method blank is processed at a minimum frequency of 1 per preparation batch. In the case of a method that has no separate preparation step (e.g. volatiles), a method blank is processed with no more than 20 samples of a specific matrix performed by the same analyst, and the same method, using the same standards or reagents.

The method blank consists of a matrix similar to the associated samples that is known to be free of the analytes of interest. Laboratories will characterize a representative matrix as “clean” if the matrix contains contaminants at less than the laboratory’s reporting limit.

Each method blank is evaluated for contamination. The source of any contamination is investigated and documented corrective action is taken when the concentration of any target analyte is detected above the reporting limit and is greater than 1/10 of the amount of that analyte found in any associated sample. Corrective actions include the re-preparation and re-analysis of all the samples, when possible, along with the full set of required quality control samples. Data qualifiers must be applied to any result reported that is associated with a contaminated method blank.

Deviations made from this policy must be approved by the Quality Manager prior to release of the data.

4.3 Laboratory Control Sample

The Laboratory Control Sample (LCS) is used to evaluate the performance of the entire analytical system including preparation and analysis.

An LCS is processed at a minimum frequency of 1 per preparation batch. In the case of a method that has no separate preparation step (e.g. volatiles), an LCS will be processed with no more than 20 samples of a specific matrix performed by the same analyst, and the same method, using the same standards or reagents.

The LCS consists of a matrix similar to the associated samples that is known to be free of the analytes of interest that is then spiked with known concentrations of target analytes.

The LCS contains **all** required analytes specified by a specific method or by the customer or regulatory agency. In the absence of specified components, the lab will spike with the following compounds:

- For multi-peak analytes (e.g. PCBs, technical chlordane, toxaphene), a representative standard will be processed.
- For methods with long lists of analytes, a representative number of target analytes may be chosen. The following criteria is used to determine the number of LCS compounds used:
    - For methods with 1-10 target compounds, the lab will spike with all compounds
    - For methods with 11-20 target compounds, the lab will spike with at least 10 compounds or 80%, whichever is greater
    - For methods with greater than 20 compounds, the lab will spike with at least 16 compounds.

The LCS is evaluated against the method default or laboratory-derived acceptance criteria. For those methods that require laboratory-derived limits, method default control limits may be used until the laboratory has a minimum of 20 (preferably greater than 30) data points from which to derive internal criteria. Any compound that is outside of these limits is considered to be ‘out of control’ and must be qualified appropriately. Any associated sample containing an ‘out-of-control' compound must either be re-analyzed with a successful LCS or reported with the appropriate data qualifier.

For LCSs containing a large number of analytes, it is statistically likely that a few recoveries will be outside of control limits. This does not necessarily mean that the system is out of control, and therefore no corrective action would be necessary (except for proper documentation). NELAC has allowed for a minimum number of marginal exceedances. The number of allowable exceedances depends on the number of compounds in the LCS. If more analyte recoveries exceed the LCS control limits than is allowed (see below), then the LCS is considered non-compliant and corrective actions are necessary. The number of allowable exceedances is as follows:

- >90 analytes in the LCS- 5 analytes
- 71-90 analytes in the LCS- 4 analytes
- 51-70 analytes in the LCS- 3 analytes
- 31-50 analytes in the LCS- 2 analytes
- 11-30 analytes in the LCS- 1 analyte
- <11 analytes in the LCS- no analytes allowed out)

Per NELAC, a matrix spike (MS) can be used in place of a non-compliant LCS in a batch as long as the MS passes the LCS acceptance criteria. When this happens, full documentation must be made available to the data user. If this is not allowed by a customer or regulatory body, the associated samples must be rerun with a compliant LCS, if possible, or reported with appropriate data qualifiers.

Deviations made from this policy must be approved by the Quality Manager prior to release of the data.

4.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

A matrix spike (MS) is used to determine the effect of the sample matrix on compound recovery for a particular method. The information from these spikes is sample or matrix specific and is not used to determine the acceptance of an entire batch unless the MS is actually used as the LCS.

A **Matrix Spike/Matrix Spike Duplicate** (MS/MSD) set is processed at a frequency specified in a particular method or as determined by a specific customer. This frequency will be specified in the applicable method SOP or customer QAPP. In the absence of such requirements, an MS/MSD set is routinely analyzed once per every 20 samples per general matrix per method.

The MS and MSD consist of the sample matrix that is then spiked with known concentrations of target analytes. Lab personnel spike customer samples that are specifically designated as MS/MSD samples or, when no designated samples are present in a batch, randomly select samples to spike that have adequate sample volume or weight. Spiked samples are prepared and analyzed in the same manner as the original samples and are selected from different customers if possible.

The MS and MSD contain all required analytes specified by a specific method or by the customer or regulatory agency. In the absence of specified components, the lab will spike with the same compounds used in the LCS.

The MS and MSD are evaluated against the method or laboratory-derived criteria. Any compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Batch acceptance, however, is based on method blank and LCS performance, not on MS/MSD recoveries. The spike recoveries give the data user a better understanding of the final results based on their site-specific information.

A matrix spike and sample duplicate will be performed instead of a matrix spike and matrix spike duplicate when specified by the customer or method.

Deviations made from this policy must be approved by the Quality Manager prior to release of the data.

4.5 Surrogates

Surrogates are compounds that reflect the chemistry of target analytes and are typically added to samples for organic analyses to monitor extraction or purging efficiency and to monitor the effect of the sample matrix on compound recovery.

For most organics analyses, surrogates are added to each customer sample, method blank, LCS and MS prior to extraction or analysis. The surrogates are evaluated against the method or laboratory-derived acceptance criteria. Any surrogate compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Samples with surrogate failures are typically re-extracted and/or re-analyzed to confirm that the out-of-control value was caused by the matrix of the sample and not by some other systematic error. An exception to this would be samples that have high surrogate values but no reportable hits for target compounds. These samples would be reported, with a qualifier, because the implied high bias would not affect the final results.

Deviations made from this policy must be approved by the Quality Manager prior to release of the data.

4.6 Sample Duplicate

A sample duplicate is a second portion of sample that is prepared and analyzed in the laboratory along with the first portion. It is used to measure the precision associated with preparation and analysis. A sample duplicate is processed at a frequency specified by the particular method or as determined by a specific customer.

The sample and duplicate are evaluated against the method or laboratory-derived criteria for relative percent difference (RPD). Any duplicate that is outside of these limits is considered to be 'out of control' and must be qualified appropriately.

Deviations made from this policy must be approved by the Quality Manager prior to release of the data.

4.7 Internal Standards

Internal Standards are method-specific analytes added to every standard, method blank, laboratory control sample, matrix spike, matrix spike duplicate, and sample at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantifying target analytes. At a minimum, the laboratory will follow method specific guidelines for the treatment of internal standard recoveries as they are related to the reporting of data.

Deviations made from this policy must be approved by the Quality Manager prior to release of the data.

4.8 Field Blanks

Field blanks are blanks prepared at the sampling site in order to monitor for contamination that may be present in the environment where samples are collected. These field quality control samples are often referenced as field blanks, rinsate blanks, or equipment blanks. The lab analyzes these field blanks as normal samples and informs the customer if there are any target compounds detected above the reporting limits.

4.9 Trip Blanks

Trip blanks are blanks that originate from the laboratory as part of the sampling event and are used to monitor for contamination of samples during transport. These blanks accompany the empty sample containers to the field and then accompany the collected samples back to the lab. These blanks are routinely analyzed for volatile methods where ambient background contamination is likely to occur.

4.10 Limit of Detection (LOD)

PASI laboratories are required to use a documented procedure to determine a limit of detection (LOD) for each analyte of concern in each matrix reported. All sample-processing steps of the preparation and analytical methods are included in this determination. For any test that does not have a valid LOD, sample results below the limit of quantitation (LOQ) cannot be reported.

The LOD is initially established for the compounds of interest for each method in a clean matrix with no target analytes present and no interferences at a concentration that would impact the results. The LOD is then determined every time there is a change in the test method that affects how the test is performed or when there has been a change in the instrument that affects the sensitivity. If required by customer, method or accreditation body, the LOD will be re-established annually for all applicable methods.

Unless otherwise noted, the method used by PASI laboratories to determine LODs is based on the Method Detection Limit (MDL) procedure outlined in 40 CFR Part 136, Appendix B. Where required by regulatory program or customer, the above referenced procedure will be followed.

Where specifically stated in the published method, LODs (or MDLs) will be performed at the listed frequency.

The validity of the LOD must be shown by detection (a value above zero) of the analytes in a QC sample in each quality system matrix. The QC sample must contain the analyte at no more than 3X the LOD for a single analyte test and 4X the LOD for multiple analyte tests. This verification must be performed on each instrument used for sample analysis and reporting of data. The validity of the LOD must be verified as part of the LOD determination process. This verification must be done prior to the use of the LOD for sample analysis.

An LOD study is not required for any analyte for which spiking solutions or quality control samples are not available (e.g. temperature).

The LOD, if required, shall be verified annually for each quality system matrix, technology and analyte. In lieu of performing full LOD (MDL) studies annually, the lab can verify the LOD (MDL) on an annual basis, providing this verification is fully documented and does not contradict other customer or program requirements that the lab must follow. The requirements of this verification are:

- The spike concentration of the verification must be no more than 3X times the LOD for single analyte tests and 4X the LOD for multiple analyte tests.
- The lab must verify the LOD on each instrument used for the reporting of sample data.
- The lab must be able to identify all target analytes in the verification standard (distinguishable from noise).

Additional information can be found in SOP S-ALL-Q-004 ***Method Detection Limit Studies*** or its equivalent revision or replacement.

4.11 Limit of Quantitation (LOQ)

A limit of quantitation (LOQ) for every analyte of concern must be determined. For PASI laboratories, this LOQ is referred to as the RL, or Reporting Limit. This RL is based on the lowest calibration standard concentration that is used in each initial calibration. Results below this level are not allowed to be reported without qualification since the results would not be substantiated by a calibration standard. For methods with a determined LOD, results can be reported out below the LOQ but above the LOD if they are properly qualified as estimated results.

There must be a sufficient buffer between the LOD and the limit of quantitation (LOQ). The LOQ must be higher than the LOD.

To verify the LOQ, the laboratory will prepare a sample in the same matrix used for the LCS. The sample will be spiked with target analytes at the concentration(s) equivalent to or less than the RL(s). This sample must undergo the routine sample preparation procedure including any routine sample cleanup steps. The sample is then analyzed and the recovery of each target analyte determined. The recovery for each target analyte must meet the laboratories control limits.

Additional information can be found in SOP S-ALL-Q-004 ***Method Detection Limit Studies*** or its equivalent revision or replacement.

4.12 Estimate of Uncertainty

PASI laboratories can provide an estimation of uncertainty for results generated by the laboratory. The estimate quantifies the error associated with any given result at a 95% confidence interval. This estimate does not include bias that may be associated with sampling. The laboratory has a procedure in place for making this estimation. In the absence of a regulatory or customer-specific procedure, PASI laboratories base this estimation on the recovery data obtained from the Laboratory Control Spikes. The uncertainty is a function of the standard deviation of the recoveries multiplied by the appropriate Student's t Factor at 95% confidence.

The measurement of uncertainty is provided only on request by the customer, as required by specification or regulation and when the result is used to determine conformance within a specification limit.

4.13 Proficiency Testing (PT) Studies

PASI laboratories participate in the NELAC-defined proficiency testing program. PT samples are obtained from NIST-approved providers and analyzed and reported at a minimum of two times per year for the relevant fields of testing per matrix.

The lab initiates an investigation whenever PT results are deemed 'unacceptable' by the PT provider. All findings and corrective actions taken are reported to the Quality Manager. A corrective action plan is initiated and this report is sent to the appropriate state accreditation agencies for their review.

PT samples are treated as typical customer samples, utilizing the same staff, methods, equipment, facilities, and frequency of analysis. PT samples are included in the laboratory's normal analytical processes and do not receive extraordinary attention due to their nature.

Comparison of analytical results with anyone participating in the same PT study is prohibited prior to the close of the study.

Additional information can be found in SOP S-ALL-Q-010 ***PE/PT Program*** or its equivalent revision or replacement.

4.14 Rounding and Significant Figures

In general, the PASI laboratories report data to no more than three significant digits. Therefore, all measurements made in the analytical process must reflect this level of precision. In the event that a process that contributes to the final result has less than three significant figures of precision, the final result must be reported with no more significant figures than that of the process in question. The rounding rules listed below are descriptive of the LIMS and not necessarily of any supporting program (Excel, etc.).

Rounding

PASI-Indianapolis follows the odd / even guidelines for rounding numbers:

- If the figure following the one to be retained is less than five, that figure is dropped and the retained ones are not changed (with three significant figures, 2.544 is rounded to 2.54).
- If the figure following the ones to be retained is greater than five, that figure is dropped and the last retained one is rounded up (with three significant figures, 2.546 is rounded to 2.55).
- If the figure following the ones to be retained is five and if there are no figures other than zeros beyond that five, then the five is dropped and the last figure retained is unchanged if it is even and rounded up if it is odd (with three significant figures, 2.525 is rounded to 2.52 and 2.535 is rounded to 2.54).

Significant Digits

PASI-Indianapolis follows the following convention for reporting to a specified number of significant figures. Unless specified by federal, state or local requirements or on specific request by a customer, the laboratory reports:

- Values > 10 – Reported to 3 significant digits
- Values ≤ 10 – Reported to 2 significant digits

5.0 DOCUMENT MANAGEMENT AND CHANGE CONTROL

5.1 Document Management

Additional information can be found in SOP S-ALL-Q-002 ***Document Management*** or its equivalent revision or replacement.

Pace Analytical Services, Inc. has an established procedure for managing documents that are part of the quality system. The list of managed documents includes, but is not limited to, Standard Operating Procedures, Quality Assurance Manuals, quality policy statements, training documents, work-processing documents, charts, posters, memoranda, notices, forms, software, and any other procedures, tables, plans, etc. that have a direct bearing on the quality system.

A master list of all managed documents is maintained at each facility identifying the current revision status of the controlled documents. This establishes that there are no invalid or obsolete documents in use in the facility. All documents are reviewed periodically and revised if necessary. Obsolete documents are systematically discarded or archived for audit or knowledge preservation purposes.

Each managed document is uniquely identified to include the date of issue, the revision identification, page numbers, and the issuing authorities. For complete information on document numbering, refer to SOP S-ALL-Q-003 ***Document Numbering*** or its equivalent revision or replacement.

SOPs, specifically, are available to all lab staff via the Learning Management System (LMS) which is a secure repository that is accessed through an internet portal. As a local alternative to the hard copy system of controlled documents, secured electronic copies of controlled documents may be maintained on the lab's local server. These document files must be read-only for all personnel except the Quality Department and system administrator. Other requirements for this system are as follows:

- Electronic documents must be readily accessible to all facility employees.
- All hardcopy SOPs must be obtained from the Quality Department.

5.1.1. Quality Assurance Manual (QAM)

The Quality Assurance Manual is the company-wide document that describes all aspects of the quality system for PASI. The base QAM template is distributed by the Corporate Quality Department to each of the regional Quality Managers. The regional management personnel modify the necessary and permissible sections of the base template and submit those modifications to the Corporate Director of Quality for review. Once approved and signed by both the CEO and the Director of Quality, the General Manager, Quality Manager and Technical Director(s) sign the Quality Assurance Manual. Each regional Quality Manager is then in charge of distribution to employees, external customers or regulatory agencies and maintaining a distribution list of controlled document copies. The Quality Assurance Manual template is reviewed on an annual basis by all of the PASI Quality Managers and revised accordingly by the Director of Quality.

5.1.2. Standard Operating Procedures (SOPs)

SOPs fall into two categories: company-wide documents (starting with the prefix S-ALL-) and facility-specific documents (starting with the individual facility prefix).

The purpose of the company-wide SOPs is to establish policies and procedure that are common and applicable to all PASI facilities. Company-wide SOPs are document-controlled by the corporate quality office and signed copies are distributed to all of the regional Quality Managers. The regional management personnel sign the company-wide SOPs. The regional Quality Manager is then in charge of distribution to employees, external customers or regulatory agencies and maintaining a distribution list of controlled document copies.

Regional PASI facilities are responsible for developing facility-specific SOPs applicable to their respective facility. The regional facility develops these facility-specific SOPs based on the corporate-wide SOP template. This template is written to incorporate a set of minimum method requirements and PASI best practice requirements. The regional facilities may add to or modify the corporate-wide SOP template provided there are no contradictions to the minimum method or best practice requirements. Facility-specific SOPs are controlled by the regional Quality Manager according to the corporate document management policies.

SOPs are reviewed every two years at a minimum (a more frequent review may be required by state or federal agencies or customers). A review of the document does not necessarily constitute a re-issue of a new revision. Documentation of this review and any applicable revisions are made in the last section of each SOP. This provides a historical record of all revisions.

All copies of superseded SOPs are removed from general use and the original copy of each SOP is archived for audit or knowledge preservation purposes. This ensures that all PASI employees use the most current version of each SOP and provides the Quality Manager with a historical record of each SOP.

Additional information can be found in SOP S-ALL-Q-001 ***Preparation of SOPs*** or its equivalent revision or replacement.

5.2 Document Change Control

Changes to managed documents are reviewed and approved in the same manner as the original review. Any revision to a document requires the approval of the applicable signatories. After revisions are approved, a revision number is assigned and the previous version of the document is officially retired. Copies may be kept for audit or knowledge preservation purposes.

All controlled copies of the previous document are replaced with controlled copies of the revised document and the superseded copies are destroyed or archived. All affected personnel are advised that there has been a revision and any necessary training is scheduled.

5.3 Management of Change

The process for documenting necessary changes within the laboratory network are not typically handled using the corrective or preventive action system as outlined in section 9.0. Management of Change is a proactive approach to dealing with change to minimize the potential negative impact of systematic change in the laboratory and to ensure that each change has a positive desired outcome. This process will primarily be used for the implementation of large scale projects and information system changes as a means to apply consistent systems or procedures within the laboratory network. The request for change is submitted by the initiator and subsequently assigned to an individual or team for development and planning. The final completion of the process culminates in final approval and verification that the procedure was effectively implemented. Additional information can be found in **SOP S-ALL-Q-034** ***Management of Change*** or its equivalent revision or replacement.

6.0 EQUIPMENT AND MEASUREMENT TRACEABILITY

Each PASI facility is equipped with sufficient instrumentation and support equipment to perform the relevant analytical testing or field procedures performed by each facility. Support equipment includes chemical standards, thermometers, balances, disposable and mechanical pipettes, etc. This section details some of the procedures necessary to maintain traceability and perform proper calibration of instrumentation and support equipment. See Attachment III for a list of equipment currently used at the Indianapolis PASI facility.

6.1 Standards and Traceability

Each PASI facility retains all pertinent information for standards, reagents and chemicals to assure traceability to a national standard. This includes documentation of purchase, receipt, preparation and use.

Upon receipt, all purchased standard reference materials are recorded into a standard logbook or database and assigned a unique identification number. The entries include the facility's unique identification number, the chemical name, manufacturer name, manufacturer's identification numbers, receipt date and expiration date. Vendor's certificates of analysis for all standards, reagents, or chemicals are retained for future reference.

Subsequent preparations of intermediate or working solutions are also documented in a standard logbook or database. These entries include the stock standard name and lot number, the solvents used for preparation, the solvent lot number, the preparation steps, preparation date, expiration dates, preparer's initials, and a unique PASI identification number. This number is used in any applicable sample preparation or analysis logbook so the standard can be traced back to the standard preparation record. This process ensures traceability back to the certificate of analysis. One-time use standards and standards or reagents that must be prepared fresh daily may not be subject to this documentation requirement.

All prepared standard or reagent containers include the PASI identification number, the standard or chemical name, the date of preparation, the date of expiration, the concentration with units, and the preparer's initials. This ensures traceability back to the standard preparation logbook.

If a second source standard is required to verify an existing calibration or spiking standard, this standard is purchased from a different supplier. If no second source is available, a second standard from a different lot may be purchased from the same supplier if the lot can be demonstrated as prepared independently from other lots.

Additional information concerning standards and reagent traceability can be found in the SOP S-ALL-Q-025 ***Standard and Reagent Preparation and Traceability*** or its equivalent revision or replacement.

6.2 General Analytical Instrument Calibration Procedures

All types of support equipment and instrumentation are calibrated or checked before use to ensure proper functioning and verify that the laboratory's requirements are met. All calibrations are performed by, or under the supervision of, an experienced analyst at scheduled intervals against either certified standards traceable to recognized national standards or reference standards whose values have been statistically validated.

Calibration standards for each parameter are chosen to establish the linear range of the instrument and must bracket the concentrations of those parameters measured in the samples. The lowest calibration standard is the lowest concentration for which quantitative data may be reported. Data reported below this level is considered to have less certainty and must be reported using appropriate data qualifiers (e.g. J flag) or explained in a narrative. The highest calibration standard is the highest concentration for which quantitative data may be reported. Data reported above this level is considered to have less certainty and must be reported using appropriate data qualifiers (e.g. E flag) or explained in the narrative. Any specific method requirement for number and type of calibration standards supersedes the general requirement. Instrument and method specific calibration criteria are explained within the specific analytical standard operating procedures for each facility.

Instrumentation or support equipment that cannot be calibrated to specification or is otherwise defective is clearly labeled as out-of-service until it has been repaired and tested to demonstrate it meets the laboratory's specifications. All repair and maintenance activities including service calls are documented in the maintenance log. Equipment sent off-site for calibration testing is packed and transported to prevent breakage and is in accordance with the calibration laboratory's recommendations.

In the event that recalibration of a piece of test equipment indicates the equipment may have been malfunctioning during the course of sample analysis, an investigation is performed. The results of the investigation along with a summary of the information reviewed are documented and maintained by the Quality Manager. If the investigation indicates sample results have been impacted, the customer is notified within 30 days. This allows for sufficient investigation and review of documentation to determine the impact on the analytical results. Instrumentation found to be consistently out of calibration is either repaired and positively verified or replaced.

Raw data records are retained to document equipment performance. Sufficient raw data is retained to reconstruct the instrument calibration and explicitly connect the continuing calibration verification to the initial calibration.

6.2.1 General Organic Calibration Procedures

Calibration standards are prepared at a minimum of five concentrations for organic analyses. Results from all calibration standards must be included in constructing the calibration curve with the following exceptions:

- The lowest level calibration standard may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done on an individual analyte basis. The reporting limit must be adjusted to the lowest concentration included in the calibration curve.
- The highest level calibration standard may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done an individual analyte basis. The upper limit of quantitation must be adjusted to the highest concentration included in the calibration curve.

- Multiple points from either the high end or the low end of the calibration curve may be excluded as long as the remaining points are contiguous in nature and the minimum number of levels remains as established by method or standard operating procedure. The reporting limit or quantitation range, which is appropriate, must be adjusted accordingly.
- Results from a concentration level between the lowest and highest calibration levels can be excluded from the calibration curve for an acceptable cause with approval from the responsible department supervisor if the results for all analytes are excluded and the point is replaced by re-analysis. Re-analysis must occur within the same 12 hour tune time period for GC/MS methodologies and within 8 hours of the initial analysis for non-GC/MS methodologies. All samples analyzed prior to the re-analyzed calibration curve point must be re-analyzed after the calibration curve is completed.

Initial calibration curves are evaluated against appropriate statistical models as required by the analytical methods. Curves that do not meet the appropriate criteria require corrective action that may include re-running the initial calibration curve. All initial calibrations are verified with a standard obtained from a second manufacturer or second lot from the same manufacturer if the lot can be demonstrated as prepared independently from other lots prior to the analysis of samples. Sample results are quantitated from the initial calibration unless otherwise required by regulation, method, or program.

The calibration curve is periodically verified by the analysis of a mid-level continuing calibration verification (CCV) standard during the course of sample analysis. Calibration verification is performed at the frequency required by the method. The verification standard must meet acceptance criteria in order for sample analysis to proceed.

In the event that the CCV does not meet the acceptance criteria, a second CCV may be analyzed as part of the diagnostic evaluation and corrective action investigation. If the second CCV is acceptable, the analytical sequence is continued. If both CCVs fail, the analytical sequence is terminated and corrective action is initiated. Sample analysis cannot begin until after documented corrective action has been completed and two consecutive CCVs have been analyzed. If required by specific state, program, or customer specification, the instrument is re-calibrated after two consecutive CCV failures. All samples analyzed since the last compliant CCV are re-analyzed for methodologies utilizing external calibration.

When instruments are operating unattended, the autosamplers may be programmed to introduce consecutive CCVs as a preventative measure against CCV failure with no corrective action. In this case, both CCVs must be evaluated to determine potential impact to the results. A summary of the decision tree and necessary documentation are listed below:

- If both CCVs meet the acceptance criteria, the analytical sequence is allowed to continue without corrective action. The 12 hour clock begins with the injection of the second CCV.
- If the first CCV does not meet the acceptance criteria and the second CCV is acceptable, the analytical sequence is continued and the results are reported.
- If the first CCV meets the acceptance criteria and the second CCV is out of control, the samples preceded by the out of control CCV must be re-analyzed in a compliant analytical sequence.

- If both CCVs are out of control, all samples since the last acceptable CCV must be re-analyzed in a compliant analytical sequence.

Some analytical methods require that samples be bracketed by passing CCVs analyzed both before and after the samples.

Some analytical methods require verification based on a time interval; some methods require a frequency based on an injection interval. The type and frequency of the calibration verifications is dependent on both the analytical method and possibly on the quality program associated with the samples. The type and frequency of calibration verification will be documented in the method specific SOP employed by each laboratory.

6.2.2 General Inorganic Calibration Procedures

The instrument is initially calibrated with standards at multiple concentrations to establish the linearity of the instrument's response. A calibration blank is also included. Initial calibration curves are evaluated against appropriate statistical models as required by the analytical methods. The number of calibration standards used depends on the specific method criteria or customer project requirements, although normally a minimum of three standards is used.

The ICP and ICP/MS can be standardized with a zero point and a single point calibration if:

- Prior to analysis, the zero point and the single point calibration are analyzed and a linear range is established,
- Zero point and single point calibration standards are analyzed with each batch
- A standard corresponding to the LOQ is analyzed with the batch and meets the established acceptance criteria
- The linearity is verified at the frequency established by the method or manufacturer.

All initial calibrations are verified with a standard obtained from a second manufacturer or second lot from the same manufacturer if the lot can be demonstrated as prepared independently from other lots prior to the analysis of samples. Sample results are quantitated from the initial calibration unless otherwise required by regulation, method, or program.

During the course of analysis, the calibration curve is periodically verified by the analysis of calibration verification standards. A calibration verification standard is analyzed within each analytical batch at method/program specific intervals to verify that the initial calibration is still valid. The CCV is also analyzed at the end of the analytical batch.

A calibration blank is also run with each calibration verification standard to verify the cleanliness of the system. All reported results must be bracketed by acceptable CCVs. Instrument and method specific calibration acceptance criteria are explained within the specific analytical standard operating procedures for each facility.

6.3 Support Equipment Calibration Procedures

All support equipment is calibrated or verified at least annually using NIST traceable references over the entire range of use. The results of calibrations or verifications must be within the specifications required or the equipment will be removed from service until repaired. The laboratory maintains records to demonstrate the correction factors applied to working thermometers.

Prior to use on each working day, balances, ovens, refrigerators, freezers, and water baths are checked in the expected use range with NIST traceable references in order to ensure the equipment meets laboratory specifications.

6.3.1 Analytical Balances

Each analytical balance is checked and, if necessary, calibrated annually by a qualified service technician. The calibration of each balance is checked each day of use with weights traceable to NIST. Calibration weights are ASTM Class 1, Class 2 or Class 3, depending on balance accuracy and are re-certified annually against a NIST traceable reference. Some accrediting agencies may require more frequent checks. If balances are calibrated by an external agency, verification of their weights must be provided. All information pertaining to balance maintenance and calibration is recorded in the individual balance logbook and/or is maintained on file in the Quality department.

6.3.2 Thermometers

Certified, or reference, thermometers are maintained for checking calibration of working thermometers. Reference thermometers are provided with NIST traceability for initial calibration and are re-certified, at a minimum, every 3 years with equipment directly traceable to NIST.

Working thermometers are compared with the reference thermometers annually according to corporate metrology procedures. Each thermometer is individually numbered and assigned a correction factor based on the NIST reference source. In addition, working thermometers are visually inspected by laboratory personnel prior to use and temperatures are documented.

Laboratory thermometer inventory and calibration data are maintained in the Quality department.

6.3.3 pH/Electrometers

The pH meter is calibrated before use each day, using fresh buffer solutions.

6.3.4 Spectrophotometers

During use, spectrophotometer performance is checked at established frequencies in analysis sequences against initial calibration verification (ICV) and continuing calibration verification (CCV) standards.

6.3.5 Mechanical Volumetric Dispensing Devices

Mechanical volumetric dispensing devices including bottle top dispensers used for critical volumes, pipettes, and burettes, excluding Class A volumetric glassware, are checked for accuracy on a quarterly basis, at a minimum. Glass microliter syringes are considered Class A glassware.

Additional information regarding calibration and maintenance of laboratory support equipment can be found in SOP S-ALL-Q-013 ***Support Equipment*** or its equivalent revision or replacement.

6.4 Instrument/ Equipment Maintenance

The objectives of the Pace Analytical maintenance program are twofold: to establish a system of instrument care that maintains instrumentation and equipment at required levels of calibration and sensitivity, and to minimize loss of productivity due to repairs.

The Laboratory Operations Manager and department manager/supervisors are responsible for providing technical leadership to evaluate new equipment, solve equipment problems and coordinate instrument repair and maintenance. The analysts have a primary responsibility to perform routine maintenance.

To minimize downtime and interruption of analytical work, preventative maintenance is routinely performed on each analytical instrument. Up-to-date instructions on the use and maintenance of equipment are available to staff in the department where the equipment is used.

Department manager/supervisors are responsible for maintaining an adequate inventory of spare parts required to minimize equipment downtime. This inventory includes parts and supplies that are subject to frequent failure, have limited lifetimes, or cannot be obtained in a timely manner should a failure occur.

All major equipment and instrumentation items are uniquely identified to allow for traceability. Equipment/instrumentation are, unless otherwise stated, identified as a system and not as individual pieces. The laboratory maintains equipment records that include the following:

- The name of the equipment
- The manufacturer’s name, type, and serial number
- Current location in the laboratory
- Copy of any manufacturer’s manuals or instructions
- Dates and results of calibrations and next scheduled calibration (if known)
- Details of past maintenance activities, both routine and non-routine
- Details of any damage, modification or major repairs

All instrument maintenance is documented in maintenance logbooks that are assigned to each particular instrument or system.

When maintenance is performed to repair an instrument problem, depending on the initial problem, demonstration of return to control may be satisfied by the successful analysis of a reagent blank or continuing calibration standard. The entry must include a summary of the results of that analysis and verification by the analyst that the instrument has been returned to an in-control status. In addition, each entry must include the initials of the analyst making the entry, the dates the maintenance actions were performed, and the date the entry was made in the maintenance logbook, if different from the date(s) of the maintenance.

Any equipment that has been subjected to overloading or mishandling, or that gives suspect results, or has been shown to be defective, is taken out of service and clearly identified. The equipment shall not be used to analyze customer samples until it has been repaired and shown to perform satisfactorily.

7.0 CONTROL OF DATA

Analytical results processing, verification and reporting are procedures employed that result in the delivery of defensible data. These processes include, but are not limited to, calculation of raw data into final concentration values, review of results for accuracy, evaluation of quality control criteria and assembly of technical reports for delivery to the data user.

All analytical data undergo a well-defined, well-documented multi-tier review process prior to being reported to the customer. This section describes procedures used by PASI for translating raw analytical data into accurate, final sample reports and PASI data storage policies.

7.1 Analytical Results Processing

When analytical, field, or product testing data is generated, it is either recorded in a bound laboratory logbook (e.g. Run log or Instrument log) or copies of computer-generated printouts are appropriately labeled and filed. These logbooks and other laboratory records are kept in accordance with each facility's Standard Operating Procedure for documentation storage and archival. If the lab chooses to minimize or eliminate its paper usage, these records can be kept as electronic records. In this case, the laboratory must ensure that there are sufficient redundant electronic copies so no data is lost due to unforeseen computer issues.

The primary analyst is responsible for initial data reduction and review. This includes confirming compliance with required methodology, verifying calculations, evaluating quality control data, noting discrepancies in logbooks and as footnotes or narratives, and uploading analytical results into the LIMS.

The primary analyst then compiles the initial data package for verification. This compilation must include sufficient documentation for data review. It may include standard calibrations, chromatograms, manual integration documentation, electronic printouts, chain-of-custody forms, and logbook copies.

Some agencies or customers require different levels of data reporting. For these special levels, the primary analyst may need to compile additional project information, such as initial calibration data or extensive spectral data, before the data package proceeds to the verification step.

7.2 Data Verification

Data verification is the process of examining data and accepting or rejecting it based on pre-defined criteria. This review step is designed to ensure that reported data are free from calculation and transcription errors, that quality control parameters are evaluated, and that any discrepancies are properly documented.

Analysts performing the analysis and subsequent data reduction have primary responsibility for quality of the data produced. The primary analyst initiates the data verification process by reviewing and accepting the data, provided QC criteria have been met for the samples being reported. Data review checklists, either hardcopy or electronic, are used to document the data review process. The primary analyst is responsible for the initial input of the data into the LIMS.

The completed data package is then sent to a designated qualified reviewer, other than the primary analyst. The following criteria have been established to qualify someone as a data reviewer. To perform secondary data reviewer, the reviewer must:

1. Have a current Demonstration of Capability (DOC) study on file and have an SOP acknowledgement form on file for the method/procedure being reviewed; or, [See Note]
2. Have a DOC on file for a similar method/technology (i.e. GC/MS) and have an SOP acknowledgment form on file for the method/procedure being reviewed; or, [See Note]
3. Supervise or manage a Department and have an SOP acknowledgment form on file for the method/procedure being reviewed; or,
4. Have significant background in the department/methods being reviewed through education or experience and have an SOP acknowledgment form on file for the method/procedure being reviewed.

Note: Secondary reviewer status must be approved personally by the Quality Manager or General Manager in the event that this person has no prior experience on the specific method or general technology (i.e. GC/MS).

This reviewer provides an independent technical assessment of the data package and technical review for accuracy according to methods employed and laboratory protocols. This assessment involves a quality control review for use of the proper methodology and detection limits, compliance to quality control protocol and criteria, presence and completeness of required deliverables, and accuracy of calculations and data quantitation. The reviewer also validates the data entered into the LIMS.

Once the data have been technically reviewed and approved, authorization for release of the data from the analytical section is indicated by initialing and dating the data review checklist or otherwise initialing and dating the data or designating the review of data electronically.

7.3 Data Reporting

Upon finalization and validation of all analyses, the Project Manager generates and reviews the Data Checker report for errors and warnings that may require additional investigation. The final report is generated once any conflicts or errors have been resolved.

Final reports are prepared according to the level of reporting required by the customer and can be transmitted to the customer via hardcopy or electronic deliverable. A standard PASI final report consists of the following components:

- A title which designates the report as “Final Report”, “Laboratory Results”, “Certificate of Results”, etc.
- Name and address of laboratory and identification of subcontractor laboratories, if used.
- Phone number and name of laboratory contact where questions can be referred.
- A unique number for the report (project number). The pages of the report shall be numbered and a total number of pages shall be indicated.
- Name and address of customer and name of project if applicable.
- Unique identification of samples analyzed including customer sample identification.

- Identification of any sample that did not meet acceptable sampling requirements, such as improper sample containers, holding times elapsed, sample temperature, chemical preservation, etc.
- Date and time of collection of samples, date of sample receipt by the laboratory, dates of sample preparation and analysis, and times of sample preparation and analysis when the holding time for either is 72 hours or less.
- Identification of the test methods used.
- Identification of sampling procedures if sampling was conducted by the laboratory.
- Deviations from, additions to, or exclusions from the test methods. These can include failed quality control indicators, deviations caused by the matrix of the sample, etc., and can be shown as a case narrative or as defined qualifiers to the analytical data.
- Identification of whether calculations were performed on a dry or wet-weight basis.
- Reporting limits used.
- Final results or measurements.
- An authentic or electronic signature and title of person accepting responsibility for the content of the report and date report was issued.
- A statement clarifying that the results of the report relate only to the samples tested or to the samples as they were received by the laboratory.
- If necessary, a statement indicating that the report must not be reproduced except in full, without the written approval of the laboratory.
- Identification of all test results provided by a subcontracted laboratory or other outside source.
- Identification of results obtained outside of quantitation levels.
- Additional items as required.

Any changes made to a final report shall be designated as “Revised” or equivalent wording. The laboratory must keep sufficient archived records of all lab reports and revisions. For higher levels of data deliverables, a copy of all applicable raw data is sent to the customer along with a final report of results. When possible, the PASI facility will provide electronic data deliverables (EDD) as required by contracts or upon customer request.

Customer data that requires transmission by telephone, telex, facsimile or other electronic means undergoes appropriate steps to preserve confidentiality.

The following positions are the only approved signatories for PASI final reports:

- Senior General Manager
- General Manager
- Quality Manager
- Client Services Manager
- Technical Director
- Project Manager
- Project Coordinator

7.4 Data Security

All data including electronic files, logbooks, extraction/digestion/distillation worksheets, calculations, project files and reports, and other information used to produce the technical report are maintained secured and retrievable by the PASI facility.

7.5 Data Archiving

All records compiled by PASI are maintained legible and retrievable and stored secured in a suitable environment to prevent loss, damage, or deterioration by fire, flood, vermin, theft, and/or environmental deterioration. Records are retained for a minimum of five years unless superseded by federal, state, contractual, and/or accreditation requirements. These records may include, but are not limited to, customer data reports, calibration and maintenance of equipment, raw data from instrumentation, quality control documents, observations, calculations and logbooks. These records are retained in order to provide for possible historical reconstruction including sampling, receipt, preparation, analysis and personnel involved. NELAP-related records will be made readily available to accrediting authorities. Access to archived data is documented and controlled by the Quality Manager or a designated Data Archivist.

Records that are computer-generated have either a hard copy or electronic write-protected backup copy. Hardware and software necessary for the retrieval of electronic data is maintained with the applicable records. Archived electronic records are stored protected against electronic and/or magnetic sources.

In the event of a change in ownership, accountability or liability, reports of analyses performed pertaining to accreditation will be maintained by the acquiring entity for a minimum of five years. In the event of bankruptcy, laboratory reports and/or records will be transferred to the customer and/or the appropriate regulatory entity upon request.

7.6 Data Disposal

Data that has been archived for the facility's required storage time may be disposed of in a secure manner by shredding, returning to customer, or utilizing some other means that does not jeopardize data confidentiality. Records of data disposal will be archived for a minimum of five years unless superseded by federal, contractual, and/or accreditation requirements.

8.0 QUALITY SYSTEM AUDITS AND REVIEWS

8.1 Internal Audits

8.1.1 Responsibilities

The Quality Manager is responsible for designing and/or conducting internal audits in accordance with a predetermined schedule and procedure. Since internal audits represent an independent assessment of laboratory functions, the auditor must be functionally independent from laboratory operations to ensure objectivity. The auditor must be trained, qualified and familiar enough with the objectives, principles, and procedures of laboratory operations to be able to perform a thorough and effective evaluation. The Quality Manger evaluates audit observations and verifies the completion of corrective actions. In addition, a periodic corporate audit will be conducted. The corporate audits will focus on the execution of the Quality System as outlined in this manual but may also include other quality programs applicable to each laboratory.

8.1.2 Scope and Frequency of Internal Audits

The complete internal audit process consists of the following four sections:

- Raw Data Review audits- conducted according to a schedule per local Quality Manager. A certain number of these data review audits are conducted per quarter to accomplish this yearly schedule.
- Quality System audits- considered the traditional internal audit function and includes analyst interviews to help determine whether practice matches method requirements and SOP language.
- Final Report reviews
- Corrective Action Effectiveness Follow-up

Internal audits are conducted annually. The scope of these audits includes evaluation of specific analytical departments or a specific quality-related system as applied throughout the laboratory.

Examples of system-wide elements that can be audited include:

- Quality Systems documents, such as Standard Operating Procedures, training documents, Quality Assurance Manual and all applicable addenda
- Personnel and training files.
- General laboratory safety protocols.
- Chemical handling practices, such as labeling of reagents, solutions, standards, and associated documentation.
- Documentation concerning equipment and instrumentation, calibration/maintenance records, operating manuals.
- Sample receipt and management practices.
- Analytical documentation, including any discrepancies and corrective actions.
- General procedures for data security, review, documentation, reporting and archiving.
- Data integrity issues such as proper manual integrations.

When the operations of a specific department are evaluated, a number of additional functions may be reviewed including:

- Detection limit studies
- Documentation of standard preparations
- Quality Control limits and Control charts

Certain projects may require an internal audit to ensure laboratory conformance to site work plans, sampling and analysis plans, QAPPs, etc.

A representative number of data audits are completed annually. The report format of any discrepancy is similar to that of other internal audits.

The laboratory, as part of their overall internal audit program, ensures that a review is conducted with respect to any evidence of inappropriate actions or vulnerabilities related to data integrity. Discovery and reporting of potential data integrity issues are handled in a confidential manner. All investigations that result in findings of inappropriate activity are fully documented, including the source of the problem, the samples and customers affected, the impact on the data, the corrective actions taken by the lab and which final reports had to be re-issued. Customers must be notified within 30 days after the data investigation is completed and impact to final results is assessed.

8.1.3 Internal Audit Reports and Corrective Action Plans

Additional information can be found in SOP S-ALL-Q-011 ***Audits and Inspections*** or its equivalent revision or replacement.

A full description of the audit, including the identification of the operation audited, the date(s) on which the audit was conducted, the specific systems examined, and the observations noted are summarized in an internal audit report. Although other personnel may assist with the performance of the audit, the Quality Manager writes and issues the internal audit report identifying which audit observations are deficiencies that require corrective action.

When audit findings cast doubt on the effectiveness of the operations or on the correctness of validity of the laboratory's environmental test results, the laboratory will take timely corrective action and notify the customer in writing within 3 business days, if investigations show that the laboratory results may have been affected.

Once completed, the internal audit report is issued jointly to the Laboratory General Manager and the manager(s)/supervisor(s) of the audited operation at a minimum. The responsible manager(s)/supervisor(s) responds within 14 days with a proposed plan to correct all of the deficiencies cited in the audit report. The Quality Manager may grant additional time for responses to large or complex deficiencies, not to exceed 30 days. Each response must include timetables for completion of all proposed corrective actions.

The Quality Manager reviews the audit responses. If the response is accepted, the Quality Manager uses the action plan and timetable as a guideline for verifying completion of the corrective action(s). If the Quality Manager determines that the audit response does not adequately address the correction of cited deficiencies, the response will be returned for modification.

To complete the audit process, the Quality Manager performs a re-examination of the areas where deficiencies were found to verify that all proposed corrective actions have been implemented. An audit deficiency is considered closed once implementation of the necessary corrective action has been audited and verified. This is usually within 60-90 days after implementation. If corrective action cannot be verified, the associated deficiency remains open until that action is completed.

8.2 External Audits

PASI laboratories are audited regularly by regulatory agencies to maintain laboratory certifications, and by customers to maintain appropriate specific protocols.

Audit teams external to the company review the laboratory to assess the existence of systems and degree of technical expertise. The Quality Manager and other QA staff host the audit team and assist in facilitation of the audit process. Generally, the auditors will prepare a formalized audit report listing deficiencies observed and follow-up requirements for the laboratory. In some cases, items of concern are discussed during a debriefing convened at the end of the on-site review process.

The laboratory staff and supervisors develop corrective action plans to address any deficiencies with the guidance of the Quality Manager. The Laboratory General Manager provides the necessary resources for staff to develop and implement the corrective action plans. The Quality Manager collates this information and provides a written report to the audit team. The report contains the corrective action plan and expected completion dates for each element of the plan. The Quality Manager follows-up with the laboratory staff to ensure corrective actions are implemented.

8.3 Quarterly Quality Reports

The Quality Manager is responsible for preparing a quarterly report to management summarizing the effectiveness of the laboratory Quality Systems. This status report will include:

- Overview of quality activities for the quarter
- Certification status
- Proficiency Testing study results
- SOP revision activities
- Company-wide 3P Document implementation (internal program)
- External audit findings
- Internal audit (method/system) findings
- Manual integration audit findings (Mintminer)
- Raw Data and Final Report review activities
- MDL activities
- Corrective action activities
- Training activity status
- Other significant Quality System items

The Corporate Director of Quality utilizes the information from each laboratory to make decisions impacting the Quality Systems of the company as a whole. Each General Manager utilizes the quarterly report information to make decisions impacting Quality Systems and operational systems at a local level.

Additional information can be found in SOP S-ALL-Q-014 ***Quality System Review*** or its equivalent revision or replacement.

8.4 Annual Managerial Review

A managerial review of Quality Systems is performed on an annual basis at a minimum. This allows for assessing program effectiveness and introducing changes and/or improvements.

The managerial review must include the following topics of discussion:

- Policy and procedure suitability
- Manager/Supervisor reports
- Internal audit results
- Corrective and preventative actions
- External assessment results
- Proficiency testing studies
- Sample capacity and scope of work changes
- Customer feedback, including complaints
- Recommendations for improvement,
- Other relevant factors, such as quality control activities, resources and staffing.

This managerial review must be documented for future reference by the Quality Manager and copies of the report are distributed to laboratory staff. Results should feed into the laboratory planning system and should include goals, objectives and action plans for the coming year. The laboratory shall ensure that any actions identified during the review are carried out within an appropriate and agreed timescale.

8.5 Customer Service Reviews

As part of the annual managerial review listed previously, the sales staff is responsible for reporting on customer feedback, including complaints. The acquisition of this information is completed by performing surveys.

The sales staff continually receives customer feedback, both positive and negative, and reports this feedback to the lab management in order for them to evaluate and improve their management system, testing activities and customer service.

In addition, the labs must be willing to cooperate with customers or their representatives to clarify customer requests and to monitor the lab's performance in relation to the work being performed for the customers.

9.0 CORRECTIVE ACTION

Additional information can be found in SOP S-ALL-Q-012 *Corrective Action/Preventive Action Process* or its equivalent revision or replacement.

During the process of sample handling, preparation and analysis, certain occurrences may warrant the necessity of corrective actions. These occurrences may take the form of analyst errors, deficiencies in quality control, method deviations, or other unusual circumstances. The Quality System of PASI provides systematic procedures for documentation, monitoring, completion of corrective actions and follow-up verification of the effectiveness of these corrective actions. This can be done using PASI's LabTrack system or other system that lists among other things, the deficiency by issue number, the deficiency source, responsible party, root cause, resolution, due date, and date resolved.

9.1 Corrective Action Documentation

The following items are examples of laboratory deviations or non-conformances that warrant some form of documented corrective action:

- Internal Laboratory Non-Conformance Trends
- PE/PT Sample Results
- Internal and External Audits
- Data Review
- Client Complaints
- Client Inquiries
- Holding Time violations

Documentation of corrective actions may be in the form of a comment or footnote on the final report that explains the deficiency (e.g. matrix spike recoveries outside of acceptance criteria) or it may be a more formal documentation (either paper system or computerized spreadsheet). This depends on the extent of the deficiency, the impact on the data, and the method or customer requirements for documentation.

The person who discovers the deficiency or non-conformance initiates the corrective action documentation on the Non-Conformance Corrective/ Preventative Action report and/or LabTrack. The documentation must include the affected projects and sample numbers, the name of the applicable Project Manager, the customer name and the sample matrix involved. The person initiating the corrective action documentation must also list the known causes of the deficiency or non-conformance as well as any corrective/preventative actions that they have taken. Preventive actions must be taken in order to prevent or minimize the occurrence of the situation.

In the event that the laboratory is unable to determine the cause, laboratory personnel and management staff will start a root cause analysis by going through an investigative process. During this process, the following general steps must be taken into account: defining the non-conformance problem, assigning responsibilities, determining if the condition is significant, and investigating the root cause of the nonconformance problem. General non-conformance investigative techniques follow the path of the sample through the process looking at each individual step in detail. The root cause must be documented within LabTrack or on the Corrective/Preventative Action Report.

After all the documentation is completed, the routing of the Corrective/Preventative Action Report and /or LabTrack will continue from the person initiating the corrective action, to their immediate supervisor or the Project Manager and finally to the Quality Manager, who is responsible for final review and signoff of all formal corrective/preventative actions.

9.2 Corrective Action Completion

9.2.1 Internal Laboratory Non-Conformance Trends

There are several types of non-conformance trends that may occur in the laboratory that would require the initiation of a corrective action report. Laboratories may choose to initiate a corrective action for all instances of one or more of these categories if they so choose, however the intent is that each of these would be handled according to its severity; one time instances could be handled with a footnote or qualifier whereas a systemic problem with any of these categories may require an official corrective action process. These categories, as defined in the Corrective Action SOP are as follows:

- Preparation Error
- Contamination
- Calibration Failure
- Internal Standard Failure
- LCS Failure
- Lab accident
- Spike Failure
- Instrument Failure
- Final Reporting error

9.2.2 PE/PT Sample Results

Any PT result returned to the Quality Manager as “not acceptable” requires an investigation and applicable corrective actions. The operational staff is made aware of the PT failures and they are responsible for reviewing the applicable raw data and calibrations and list possible causes for error. The Quality Manager reviews their findings and initiates another external PT sample or an internal PT sample to try and correct the previous failure. Replacement PT results must be monitored by the Quality Manager and reported to the applicable regulatory authorities.

9.2.3 Internal and External Audits

The Quality Manager is responsible for documenting all audit findings and their corrective actions. This documentation must include the initial finding, the persons responsible for the corrective action, the due date for reporting back to the auditing body, the root cause of the issue, and the corrective action taken to resolve the findings. The Quality Manager is also responsible for providing any back-up documentation used to prove that a corrective action has been completed.

9.2.4 Data Review

In the course of performing primary and secondary review of data or in the case of raw data reviews by the Quality Department, errors may be found which require corrective actions.

Any finding that affects the quality of the data requires some form of corrective action, which may include revising and re-issuing of final reports.

9.2.5 Client Complaints

Project Managers are responsible for issuing corrective action forms for customer complaints. As with other corrective actions, the possible causes of the problem are listed and the form is passed to the appropriate analyst or supervisor. After the corrective actions have been listed, the Project Manager reviews the corrective action to determine if the customer needs or concerns are being addressed.

9.2.6 Client Inquiries

When an error on the customer report is discovered, the Project Manager is responsible for initiating a formal corrective action form that describes the failure (e.g. incorrect analysis reported, reporting units are incorrect, reporting limits do not meet objectives). The Project Manager is also responsible for revising the final report if necessary and submitting it to the customer.

9.2.7 Holding Time Violations

In the event that a holding time requirement has been missed, the analyst or supervisor must complete a formal corrective action form. The Project Manager and the Quality Manager must be made aware of these holding time violations.

The Project Manager must contact the customer for appropriate decisions to be made with the resolution documented and included in the customer project file. The Quality Manager includes a list of all missed holding times in their Quarterly Report to the corporate office.

9.3 Preventive Action Documentation

Pace laboratories can take advantage of several available information sources in order to identify needed improvements in all systems (technical, managerial, quality, etc.). These sources may include:

- Management Continuous Improvement Plan (CIP) metrics which are used by all production departments within Pace. When groups compare performance across the company, ways to improve systems are discovered. These improvements can be made within a department or lab-wide.
- Annual managerial reviews- part of this NELAC-required and NVLAP-required review is to look at all processes and procedures used by the lab over the past year and to determine ways to improve these processes in the future.
- Quality systems reviews- any frequent checks of quality systems (monthly quality systems checks, etc.) can uncover issues that can be corrected or adjusted before they become a larger issue.

When improvement opportunities are identified or if preventive action is required, the lab can develop, implement, and monitor preventive action plans.

10.0 GLOSSARY

3P Program	The Pace Analytical continuous improvement program that focuses on Process, Productivity and Performance. Best Practices are identified that can be used by all PASI labs.
Accuracy	The agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; a data quality indicator.
Aliquot	A portion of a sample taken for analysis.
Analysis Code (Acode)	All the set parameters of a test, such as Analytes, Method, Detection Limits and Price.
Analyte	The specific chemical species or parameter an analysis seeks to determine.
Analytical Uncertainty	A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.
Atomic Absorption Spectrometer	Instrument used to measure concentration in metals samples.
Audit	A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.
Batch	Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A preparation batch is composed of one to 20 environmental samples of the same NELAC-defined matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An analytical batch is composed of prepared environmental samples (extracts, digestates or concentrates) that are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples.
Bias	The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).
Blank	A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results.
Blind Sample	A sample for submitted for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test analyst or laboratory proficiency in the execution of the measurement process.
BNA (Base Neutral Acid compounds)	A list of semi-volatile compounds typically analyzed by mass spectrometry methods. Named for the way they can be extracted out of environmental samples in an acidic, basic or neutral environment.
BOD (Biochemical Oxygen Demand)	Chemical procedure for determining how fast biological organisms use up oxygen in a body of water.

Calibration	To determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter, instrument, or other device. The levels of the applied calibration standard must bracket the range of planned or expected sample measurements.
Calibration Curve	The graphic representation of known values, such as concentrations for a series of calibration standards and their instrument response.
Calibration Verification	The process of verifying a calibration by analysis of standards and comparing the results with the known amount.
Chain-of-Custody (COC)	A record that documents the possession of samples from the time of collection to receipt in the laboratory. This record generally includes the number and type of containers, mode of collection, collector, time of collection, preservation, and requested analyses.
Chemical Oxygen Demand (COD)	A test commonly used to indirectly measure the amount of organic compounds in water.
Code of Federal Regulations (CFR)	A codification of the general and permanent rules published in the Federal Register by agencies of the federal government.
Comparability	An assessment of the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.
Completeness	The percent of valid data obtained from a measurement system compared to the amount of valid data expected under normal conditions. The equation for completeness is: % Completeness = (Valid Data Points/Expected Data Points)*100
Confirmation	Verification of the identity of a component through the use of an alternate scientific approach from the original method. These may include, but are not limited to: • second-column confirmation • alternate wavelength • derivatization derivative • mass spectral interpretation • additional cleanup procedures
Continuing Calibration Blank (CCB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method.
Continuing Calibration Check Compounds (CCC)	Compounds listed in mass spectrometry methods that are used to evaluate an instrument calibration from the standpoint of the integrity of the system. High variability would suggest leaks or active sites on the instrument column.
Continuing Calibration Verification (CCV)	Also referred to as a CVS in some methods, it is a standard used to verify the initial calibration of compounds in an analytical method. CCVs are analyzed at a frequency determined by the analytical method.
Continuous Emission Monitor (CEM)	A flue gas analyzer designed for fixed use in checking for environmental pollutants.
Contract Laboratory Program (CLP)	A national network of EPA personnel, commercial labs, and support contractors whose fundamental mission is to provide data of known and documented quality.
Contract Required Detection Limit (CRDL)	Detection limit that is required for EPA Contract Laboratory Program (CLP) contracts.

Contract Required Quantitation Limit (CRQL)	Quantitation limit (reporting limit) that is required for EPA Contract Laboratory Program (CLP) contracts.
Control Chart	A graphic representation of a series of test results, together with limits within which results are expected when the system is in a state of statistical control (see definition for Control Limit)
Control Limit	A range within which specified measurement results must fall to verify that the analytical system is in control. Control limit exceedances may require corrective action or require investigation and flagging of non-conforming data.
Corrective Action	The action taken to eliminate the causes of a non-conformity, defect, or other undesirable situation in order to prevent recurrence.
Corrective and Preventative Action (CAPA)	The primary management tools for bringing improvements to the quality system, to the management of the quality system's collective processes, and to the products or services delivered which are an output of established systems and processes.
Data Quality Objective (DQO)	Systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use or end user.
Data Reduction	The process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more usable form.
Demonstration of Capability	A procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision.
Diesel Range Organics (DRO)	A range of compounds that denote all the characteristic compounds that make up diesel fuel (range can be state or program specific).
Document Control (Management)	Procedures to ensure that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled (managed) to ensure use of the correct version at the location where the prescribed activity is performed.
Dry Weight	The weight after drying in an oven at a specified temperature.
Duplicate or Replicate Analysis	The identically performed measurement on two or more sub-samples of the same sample within a short interval of time
Electron Capture Detector (ECD)	Device used in GC methods to detect compounds that absorb electrons (e.g. PCB compounds).
Electronic Data Deliverable (EDD)	A summary of environmental data (usually in spreadsheet form) which clients request for ease of data review and comparison to historical results.
Environmental Sample	A representative sample of any material (aqueous, non-aqueous, or multimedia) collected from any source for which determination of composition or contamination is requested or required. Environmental samples can generally be classified as follows: • Non Potable Water (Includes surface water, ground water, effluents, water treatment chemicals, and TCLP leachates or other extracts) • Drinking Water - Delivered (treated or untreated) water designated as potable water • Water/Wastewater - Raw source waters for public drinking water supplies, ground waters, municipal influents/effluents, and industrial influents/effluents • Sludge - Municipal sludges and industrial sludges. • Soil - Predominately inorganic matter ranging in classification from sands to clays. • Waste - Aqueous and non-aqueous liquid wastes, chemical solids, and industrial liquid and solid wastes

Equipment Blank	A sample of analyte-free media used to rinse common sampling equipment to check effectiveness of decontamination procedures.
Field Blank	A blank sample prepared in the field by filling a clean container with reagent water and appropriate preservative, if any, for the specific sampling activity being undertaken.
Field Measurement	Determination of physical, biological, or radiological properties, or chemical constituents that are measured on-site, close in time and space to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory.
Field of Accreditation	Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.
Finding	An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement.
Flame Atomic Absorption Spectrometer (FAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the fact that ground state metals absorb light at different wavelengths. Metals in a solution are converted to the atomic state by use of a flame.
Flame Ionization Detector (FID)	A type of gas detector used in GC analysis where samples are passed through a flame which ionizes the sample so that various ions can be measured.
Gas Chromatography (GC)	Instrumentation which utilizes a mobile carrier gas to deliver an environmental sample across a stationary phase with the intent to separate compounds out and measure their retention times.
Gas Chromatograph/ Mass Spectrometry (GC/MS)	In conjunction with a GC, this instrumentation utilizes a mass spectrometer which measures fragments of compounds and determines their identity by their fragmentation patterns (mass spectra).
Gasoline Range Organics (GRO)	A range of compounds that denote all the characteristic compounds that make up gasoline (range can be state or program specific).
Graphite Furnace Atomic Absorption Spectrometry (GFAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the absorption of light at different wavelengths that are characteristic of different analytes.
High Pressure Liquid Chromatography (HPLC)	Instrumentation used to separate, identify and quantitate compounds based on retention times which are dependent on interactions between a mobile phase and a stationary phase.
Holding Time	The maximum time that samples may be held prior to preparation and/or analysis as defined by the method.
Homogeneity	The degree to which a property or substance is uniformly distributed throughout a sample.
Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)	Analytical technique used for the detection of trace metals which uses plasma to produce excited atoms that emit radiation of characteristic wavelengths.
Inductively Coupled Plasma- Mass Spectrometry (ICP/MS)	An ICP-AES that is used in conjunction with a mass spectrometer so that the instrument is not only capable of detecting trace amounts of metals and non-metals but is also capable of monitoring isotopic speciation for the ions of choice.
Infrared Spectrometer (IR)	An instrument that uses infrared light to identify compounds of interest.

Initial Calibration (ICAL)	The process of analyzing standards, prepared at specified concentrations, to define the quantitative response relationship of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a calibration verification standard do not conform to the requirements of the method in use or at a frequency specified in the method.
Initial Calibration Verification (ICV)	A standard (usually from a second source or otherwise required vendor) analyzed after the initial calibration curve to verify that the curve is valid.
Internal Standards	A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.
Intermediate Standard Solution	Reference solutions prepared by dilution of the stock solutions with an appropriate solvent.
Ion Chromatography (IC)	Instrumentation or process that allows the separation of ions and molecules based on the charge properties of the molecules.
Laboratory Control Sample (LCS)	(however named, such as laboratory fortified blank, spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.
Laboratory Information Management System (LIMS)	A computer system that is used to maintain all sample information from sample receipt, through preparation and analysis and including sample report generation.
LabTrack	Database used by Pace Analytical to store and track corrective actions and other laboratory issues.
Learning Management System (LMS)	A training database used by Pace Analytical to train their employees. This system is a self-paced system which is capable of tracking all employee training requirements and documentation.
Legal Chain-of-Custody	Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain-of-Custody Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.
Limit of Detection (LOD)	A laboratory's estimate of the minimum amount of an analyte in a given matrix that an analytical process can reliably detect in their facility. An LOD is analyte and matrix specific and may be lab-dependent.
Limit of Quantitation (LOQ)	The minimum levels, concentrations or quantities of a target variable (e.g. target analyte) that can be reported with a specified degree of confidence.
Laboratory Information Management System (LIMS)	A computer system that is used to maintain all sample information from sample receipt, through preparation and analysis and including sample report generation.
Learning Management System (LMS)	A web-based database used by the laboratories to track and document training activities. The system is administered by the corporate training department and each lab's learn centers are maintained by a local administrator.
Lot	A quantity of bulk material of similar composition processed or manufactured at the same time.

Matrix Duplicate	A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.
Matrix Spike (MS) (spiked sample or fortified sample)	A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known amount of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Matrix Spike Duplicate (MSD) (spiked sample or fortified sample duplicate)	A replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of precision of the recovery of each analyte.
Method	A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis) systematically presented in the order in which they are to be executed.
Method Blank	A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures: and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.
Method Detection Limit (MDL)	One way to establish a Limit of Detection (LOD); defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.
MintMiner	Program used by Pace Analytical to review large amounts of chromatographic data to monitor for errors or data integrity issues.
National Pollutant Discharge Elimination System (NPDES)	A permit program that controls water pollution by regulating point sources that discharge pollutants into U.S. waters.
Nitrogen Phosphorus Detector (NPD)	A detector used in GC analyses that utilizes thermal energy to ionize an analyte. With this detector, nitrogen and phosphorus can be selectively detected with a higher sensitivity than carbon.
Not Detected (ND)	The result reported for a compound when the detected amount of that compound is less than the method reporting limit.
Performance Based Measurement System (PBMS)	An analytical system wherein the data quality needs, mandates or limitations of a program or project are specified and serve as criteria for selecting appropriate test methods to meet those needs in a cost-effective manner.
Photo-ionization Detector (PID)	An ion detector which uses high-energy photons, typically in the ultraviolet range, to break molecules into positively charged ions.
Polychlorinated Biphenyls (PCB)	A class of organic compounds that were used as coolants and insulating fluids for transformers and capacitors. The production of these compounds was banned in the 1970's due to their high toxicity.
Power of Hydrogen (pH)	The measure of acidity or alkalinity of a solution.
Practical Quantitation Limit (PQL)	Another term for a method reporting limit. The lowest reportable concentration of a compound based on parameters set up in an analytical method and the lab's ability to reproduce those conditions.
Precision	The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation	Any conditions under which a sample must be kept in order to maintain the chemical and/or biological integrity of the sample.
Proficiency Testing	A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.
Proficiency Testing Sample	A sample, the composition of which is unknown to the laboratory and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.
Protocol	A detailed written procedure for field and/or laboratory operation that must be strictly followed.
Quality Assurance (QA)	An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.
Quality Assurance Manual (QAM)	A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality Assurance Project Plan (QAPP)	A formal document describing the detailed quality control procedures required by a specific project.
Quality Control (QC)	The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring that the results are of acceptable quality.
Quality Control Sample (QCS)	A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking, intended to demonstrate that a measurement system or activity is in control.
Quality System	A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

Quality System Matrix	These matrix definitions are to be used for purposes of batch and quality control requirements: • **Air and Emissions**: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbant tube, impinger solution, filter, or other device • **Aqueous**: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, groundwater effluents, and TCLP or other extracts. • **Biological Tissue**: Any sample of a biological origin such as fish tissue, shellfish or plant material. Such samples shall be grouped according to origin • **Chemical Waste**: A product or by-product or an industrial process that results in a matrix not previously defined. • **Drinking Water**: Any aqueous sample that has been designated a potable or potentially potable water source. • **Non-aqueous liquid**: Any organic liquid with <15% settleable solids • **Saline/Estuarine**: Any aqueous sample from an ocean or estuary, or other saltwater source such as the Great Salt Lake. • **Solids**: Includes soils, sediments, sludges, and other matrices with >15% settleable solids.
Random Error	The EPA has established that there is a 5% probability that the results obtained for any one analyte will exceed the control limits established for the test due to random error. As the number of compounds measured increases in a given sample, the probability for statistical error also increases.
Raw Data	The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, printouts of chromatograms, instrument outputs, and handwritten records.
Reagent Grade	Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents that conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.
Reference Standard	Standard used for the calibration of working measurement standards in a given organization or at a given location.
Relative Percent Difference (RPD)	A measure of precision defined as the difference between two measurements divided by the average concentration of the two measurements.
Reporting Limit (RL)	The level at which method, permit, regulatory and customer-specific objectives are met. The reporting limit may never be lower than the Limit of Detection (i.e. statistically determined MDL). Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified. There must be a sufficient buffer between the Reporting Limit and the MDL.
Reporting Limit Verification Standard (or otherwise named)	A standard analyzed at the reporting limit for an analysis to verify the lab's ability to report to that level.
Representativeness	A quality element related to the ability to collect a sample reflecting the characteristics of the part of the environment to be assessed. Sample representativeness is dependent on the sampling techniques specified in the project work plan.
Sample Condition Upon Receipt Form (SCURF)	Form used by Pace Analytical sample receiving personnel to document the condition of sample containers upon receipt to the laboratory (used in conjunction with a COC).

Sample Delivery Group (SDG)	A unit within a single project that is used to identify a group of samples for delivery. An SDG is a group of 20 or fewer field samples within a project, received over a period of up to 14 calendar days. Data from all samples in an SDG are reported concurrently.
Sample Receipt Form (SRF)	Letter sent to the client upon login to show the tests requested and pricing.
Sample Tracking	Procedures employed to record the possession of the samples from the time of sampling until analysis, reporting and archiving. These procedures include the use of a Chain-of-Custody Form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.
Sampling	Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure.
Selective Ion Monitoring (SIM)	A mode of analysis in mass spectrometry where the detector is set to scan over a very small mass range, typically one mass unit. The narrower the range, the more sensitive the detector.
Sensitivity	The capability of a method or instrument to discriminate between measurement responses representing different levels (concentrations) of a variable of interest.
Standard	A substance or material with properties known with sufficient accuracy to permit its use to evaluate the same property in a sample.
Standard Blank (or Reagent Blank)	A calibration standard consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.
Standard Operating Procedure (SOP)	A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks
Statement of Qualifications (SOQ)	A document that lists information about a company, typically the qualifications of that company to compete on a bid for services.
Stock Standard	A concentrated reference solution containing one or more analytes prepared in the laboratory using an assayed reference compound or purchased from a reputable commercial source.
Surrogate	A substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them for quality control purposes.
Systems Audit	An on-site inspection or assessment of a laboratory's quality system.
Test Methods for Evaluating Solid Waste, Physical/ Chemical (SW-846)	EPA Waste's official compendium of analytical and sampling methods that have been evaluated and approved for use in complying with RCRA regulations.
Total Petroleum Hydrocarbons (TPH)	A term used to denote a large family of several hundred chemical compounds that originate from crude oil. Compounds may include gasoline components, jet fuel, volatile organics, etc.
Toxicity Characteristic Leaching Procedure (TCLP)	A solid sample extraction method for chemical analysis employed as an analytical method to simulate leaching of compounds through a landfill.

Traceability	The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical conditions or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.
Training Document	A training resource that provides detailed instructions to execute a specific method or job function.
Trip Blank	This blank sample is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory reagent water and the blank is stored, shipped, and analyzed with its associated samples.
Ultraviolet Spectrophotometer (UV)	Instrument routinely used in quantitative determination of solutions of transition metal ions and highly conjugated organic compounds.
Uncertainty Measurement	The parameter associated with the result of a measurement that characterized the dispersion of the values that could be reasonably attributed to the measurand (i.e. the concentration of an analyte).
Verification	Confirmation by examination and objective evidence that specified requirements have been met.
Whole Effluent Toxicity (WET)	The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent).

11.0 REFERENCES

- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136.
- "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846.
- "Methods for Chemical Analysis of Water and Wastes", EPA 600-4-79-020, 1979 Revised 1983, U.S. EPA.
- U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis
- U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis
- "Standard Methods for the Examination of Water and Wastewater." Current Edition APHA-AWWA-WPCF
- "Annual Book of ASTM Standards", Section 4: Construction, Volume 04.04: Soil and Rock; Building Stones, American Society of Testing and Materials.
- "Annual Book of ASTM Standards", Section 11: Water and Environmental Technology, American Society of Testing and Materials.
- "NIOSH Manual of Analytical Methods", Third Edition, 1984, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.
- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory – Cincinnati (September 1986).
- Quality Assurance of Chemical Measurements, Taylor, John K.; Lewis Publishers, Inc. 1987
- Environmental Measurements Laboratory (EML) Procedures Manual, HASL-300, US DOE, February, 1992.
- Requirements for Quality Control of Analytical Data, HAZWRAP, DOE/HWP-65/R1, July, 1990.
- Requirements for Quality Control of Analytical Data for the Environmental Restoration Program, Martin Marietta, ES/ER/TM-16, December, 1992.
- Quality Assurance Manual for Industrial Hygiene Chemistry, AIHA, 1988
- National Environmental Laboratory Accreditation Conference, Constitution, Bylaws, and Standards. Most recent
- ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories.

12.0 REVISIONS

The PASI Corporate Quality and Safety Manager files both a paper copy and electronic version of a Microsoft Word document with tracked changes detailing all revisions made to the previous version of the Quality Assurance Manual. This document is available upon request. All revisions are summarized in the table below.

Document Number	Reason for Change	Date
Quality Assurance Manual Revision 12.0	General: replaced the word ‘client’ with ‘customer’, where applicable. Section 1.6.4: added language for clarity Added new section 1.8.1; responsibilities of Senior General Managers. Section 1.8.3: added reference to LMS. Added new section 1.8.17: responsibilities of Waste Coordinators. Section 1.9, last paragraph: changed ‘annually’ to ‘periodically’. Next to last paragraph- added reference to LMS. Added new section 2.2 entitled Field Services. Section 2.3: added reference to the new Review of Analytical Requests SOP. Section 2.7.2: changed freezer temp requirement to match SOP. Section 4.10: revised and added language regarding LOD studies, initial verification and annual verification, where applicable. Section 4.11: changed PRL to RL. Section 4.13: added editable line regarding PT study information. Section 4.14: added sentence regarding rounding rules listed applying only to LIMS. Section 5.1, last bullet point: changed language to reflect that SOPs must be locked from printing if controlled electronically. Section 6.3.1: adjusted language about classes of weights potentially used. Section 6.3.3: removed customer-specific requirement to re-calibrate every four hours but added space for this to be added back in where applicable. Added reference to Attachment III in the introductory paragraph to section 6. Sections 7.1-7.3: added language for those labs that are minimizing or eliminating the need for paper copies. Section 7.2: clarified language in numbered items so that it does not appear that all 4 criteria must be applicable at one time. Section 7.3: added list of approved signatories for final reports. Section 8.1.2, last paragraph: revised language regarding data integrity issues and added a timeframe to notify customers of affected data. Added section 8.5 “Customer Service Reviews”- ISO requirement Added new section 9.3 regarding Preventive Action. Attachment IIb: updated corporate org chart Attachment VIII: revised to match the current Analytical Guides.	13Nov2008

Document Number	Reason for Change	Date
Quality Assurance Manual revision 13.0	Increased font size of entire document. Section 1.7, fifth paragraph: changed length of time Technical Director can be gone before contacting primary authority (from 65 down to 35 days per TNI standard). Section 1.8.3`: Reworded definition for Assistant GM to say "all departments". Section 1.8: Removed Field Technician and Field Analyst positions Fixed numbering issue with sub-sections for section 1.8 and used bullet points instead of numbers. Section 1.8.17: revised position title to capture requirement of some labs. Section 1.9: added language to second bullet point regarding LMS. Section 1.9: added bullet point for on-line courses. Section 2.5: added third note per request from GB (in red text). Section 2.6: Added chart of 2-digit codes (lab designations) per audit finding from GB lab (matches corporate SOPs). Section 2.7.4: added reference for Waste Handling and Management SOT. Section 3.1: added more method agency references. Section 3.4: added reference to Training SOP at end of section. Section 4.1: fixed numbering issue. Removed anonymous phone number and added reference to the Employee Handbook. Section 4.3, fifth paragraph: reworded second sentence for clarity. Section 4.4, first paragraph: added qualifier to end of paragraph that MS limits are used to assess the batch if the MS is used in place of the LCS. Section 5.1, fifth paragraph: changed wording from LAN/WAN to local server (as opposed to hardcopies) and added language about LMS access. Added new section 5.3- Management of Change. Section 8.1.2, last sentence: reworded to match current practice. Section 8.1.3, last paragraph: reworded sentences regarding verification of corrective actions. Section 8.3: revised list of Quarterly Quality report items to match the revised SOP. Section 8.4: added last two bullet points and added second line of last paragraph to match ISO language. Section 9.1: changed bullet point items to match CAR SOP. Section 9.2.1: revised language to match SOP. Section 9.2.2: moved language from old 9.2.8 to 9.2.2. Section 9.2.4: added language to data review section. Glossary: Added definitions for analytical uncertainty, audit, bias, field of accreditation, finding, legal COC, matrix duplicate, method, PT sample, sampling, verification (per TNI standard). Glossary: Added definitions for reporting limit verification standard and initial calibration verification per request. Glossary: revised the following definitions to match new TNI language: DOC, LCS, LOD, MS, MSD, preservation, QA, QC, QC sample, raw data, reference standard, SOPs, and traceability. Also revised language within the definition for Quality System Matrix (previously just called Matrix). Glossary: deleted definition for 'detection limit'. Glossary: added definitions from company Acronym form from IT. Glossary: added definitions for LabTrack and MintMiner. Attachment VIII: added more tests to the chart per QM input including a line item for concentrated waste matrix for VOA 8260. General: removed all reference to DoD and Ohio VAP. General: changed all references to "Director of Quality, Safety, and Training" to "Director of Quality". General: revised document references to SOTs for Waste Handling and Management and Sample Management. Removed corporate org chart from Attachment IIB and will provide this as a separate document to the QMs. In this way, revisions to the corporate org chart will not necessitate a new QAM revision.	30Apr2010

ATTACHMENT I

Quality Control Calculations

PERCENT RECOVERY (%REC)

$$\%REC = \frac{(MSConc - SampleConc)}{TrueValue} * 100$$

NOTE: The SampleConc is zero (0) for theLCS and Surrogate Calculations

PERCENT DIFFERENCE (%D)

$$\%D = \frac{MeasuredValue - TrueValue}{TrueValue} * 100$$

where:
TrueValue = Amount spiked (can also be the $\overline{CF}$ or $\overline{RF}$ of the ICAL Standards)
Measured Value = Amount measured (can also be the CF or RF of the CCV)

PERCENT DRIFT

$$\%Drift = \frac{CalculatedConcentration - TheoreticalConcentration}{TheoreticalConcentrtion} * 100$$

RELATIVE PERCENT DIFFERENCE (RPD)

$$RPD = \frac{|(R1 - R2)|}{(R1 + R2)/2} * 100$$

where:
R1 = Result Sample 1
R2 = Result Sample 2

CORRELATION COEFFICIENT (R)

$$CorrCoeff = \frac{\sum_{i=1}^{N} W_i * (X_i - \overline{X}) * (Y_i - \overline{Y})}{\sqrt{\left(\sum_{i=1}^{N} W_i * (X_i - \overline{X})^2\right) * \left(\sum_{i=1}^{N} W_i * (Y_i - \overline{Y})^2\right)}}$$

With:	N	Number of standard samples involved in the calibration
	i	Index for standard samples
	Wi	Weight factor of the standard sample no. i
	Xi	X-value of the standard sample no. i
	X(bar)	Average value of all x-values
	Yi	Y-value of the standard sample no. i
	Y(bar)	Average value of all y-values

ATTACHMENT I (CONTINUED)

Quality Control Calculations (continued)

STANDARD DEVIATION (S)

$$S = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{(n-1)}}$$

where:
n = number of data points
X_i = individual data point
$\overline{X}$ = average of all data points

AVERAGE ($\overline{X}$)

$$\overline{X} = \frac{\sum_{n=1}^{i} X_i}{n}$$

where:
n = number of data points
X_i = individual data point

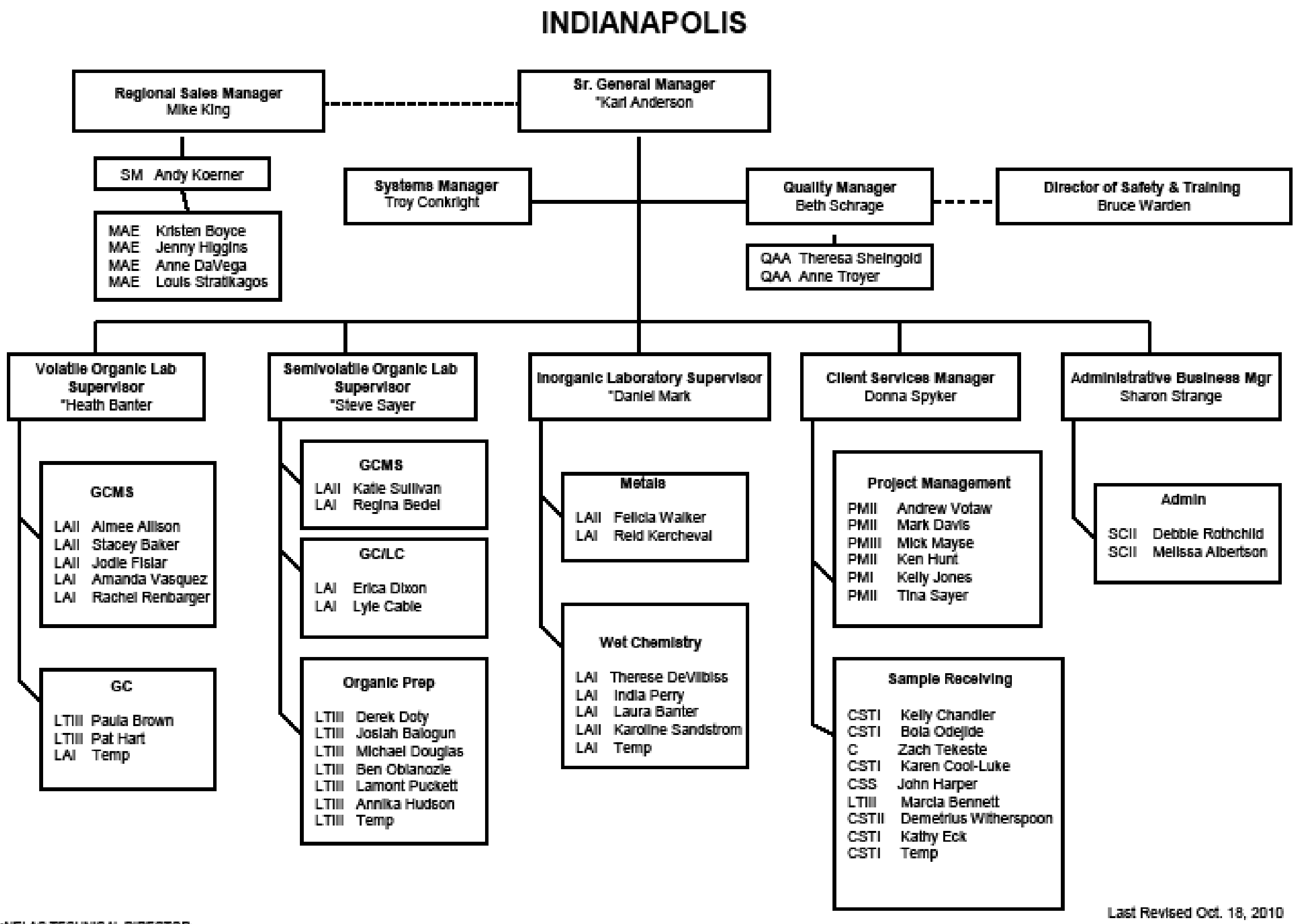
RELATIVE STANDARD DEVIATION (RSD)

$$RSD = \frac{S}{\overline{X}} * 100$$

where:
S = Standard Deviation of the data points
$\overline{X}$ = average of all data points

ATTACHMENT IIA

PASI – *INDIANAPOLIS* ORGANIZATIONAL CHART

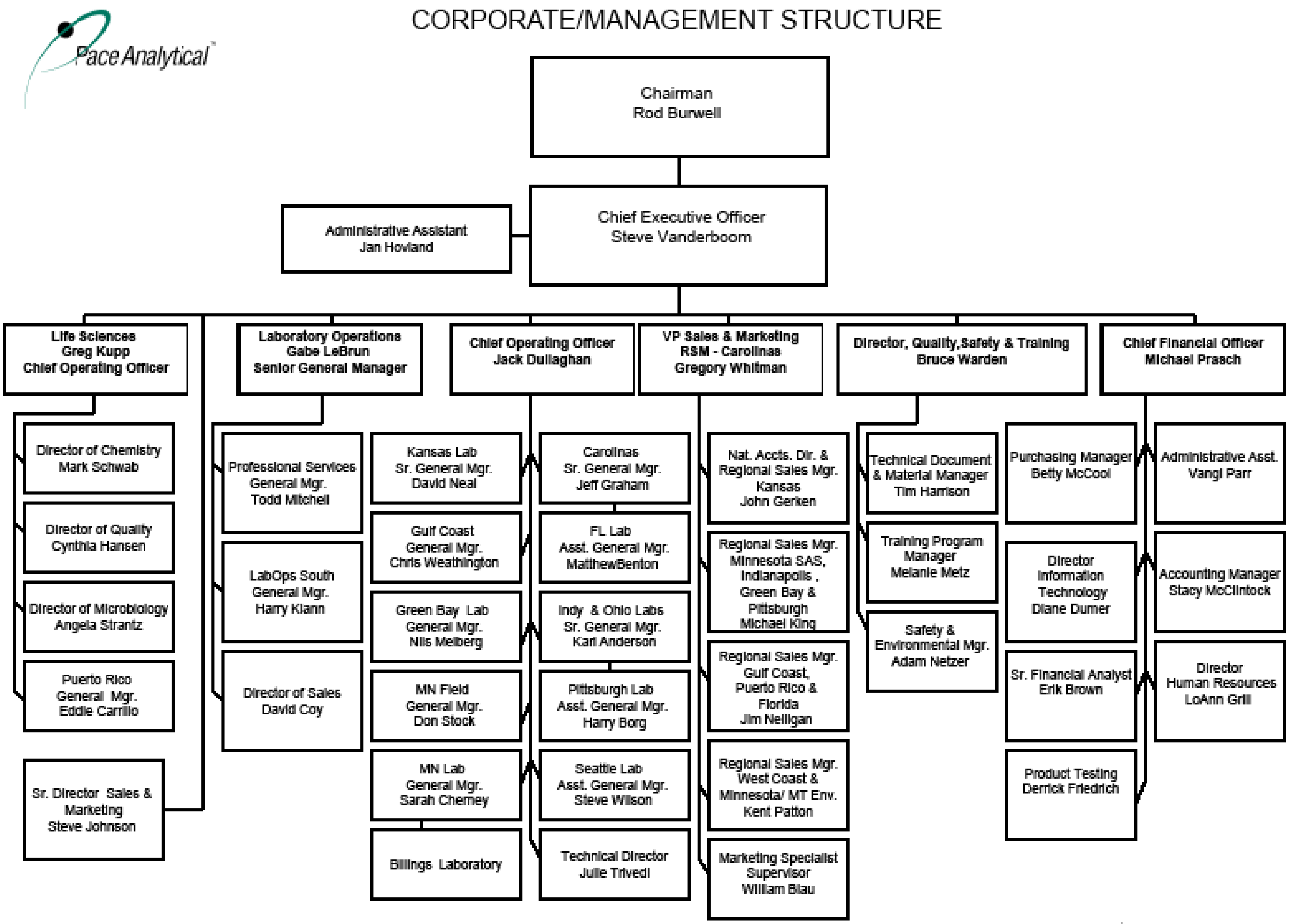


Last Revised Oct. 18, 2010

*NELAC TECHNICAL DIRECTOR

ATTACHMENT IIB

PASI – CORPORATE ORGANIZATIONAL CHART



________________________ Date ________ May,2010
Steve Vanderboom, Chief Executive Officer

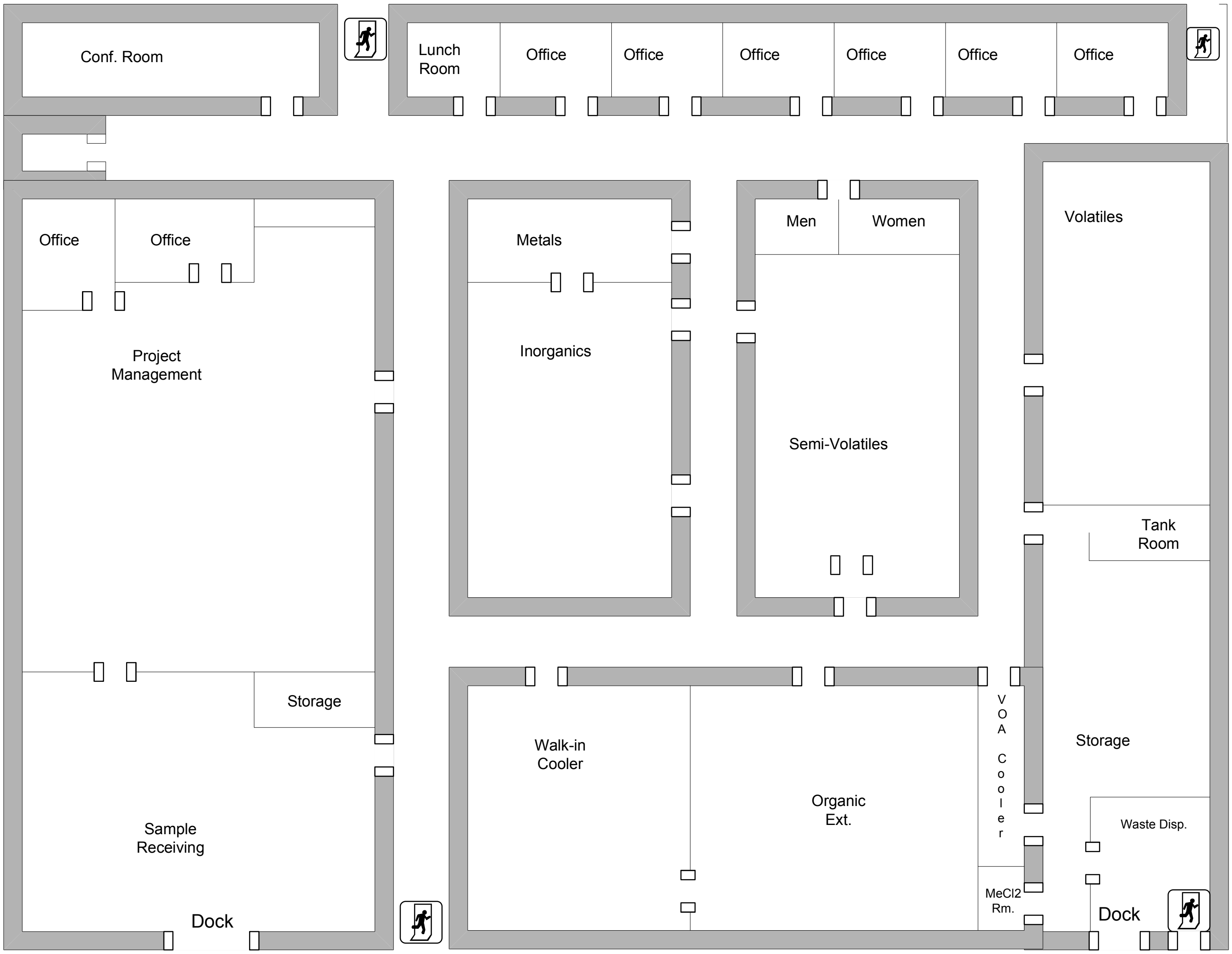
ATTACHMENT III

PASI – INDIANAPOLIS EQUIPMENT LIST

INSTRUMENT	MANUFACTURER	MODEL NUMBER	DETECTOR	AUTOSAMPLER	SERVICE ANALYSIS	AGE (yrs)
GC/MS (50MSV1)	Hewlett-Packard	6890	MS (5973)	Archon/PT2	8260/624/5035	5
GC/MS (50MSV2)	Hewlett-Packard	5890	MS (5971A)	Centurion/PT2	8260/624	9
GC/MS (50MSV3)	Hewlett-Packard	6890	MS (5973)	Archon/PT2	8260/624/5035	6
GC/MS (50MSV4)	Agilent	6850N	MS (5975B)	Centurion/PT2	8260/624/524.2	1
GC/MS (50MSV5)	Agilent	6890	MS (5973)	Archon/PT2	8260/624/5035	5
GC/MS (50MSV6)	Agilent	6850N	MS (5975C)	Centurion WS	8260/624/5035	<1
GC/MS (50MSS1)	Hewlett-Packard	6890	MS (5973)	HP 7683	8270 PAH SIM	6
GC/MS (50MSS2)	Agilent	7890	MS (5975)	7683B	8270 BNA	1
GC/MS (50MSS3)	Agilent	7890	MS (5975)	7683B	8270 BNA	1
GC/MS (50MSS4)	Agilent	6890	MS (5975)	7683B	8270 PAH SIM	2
Gas Chromatograph (50GCS1)	Hewlett-Packard	5890	FID	HP 7673	IH / special projects	9
Gas Chromatograph (50GCS2)	Hewlett-Packard	5890	FID	HP 7673	8015 Alcohols/Glycols	9
Gas Chromatograph (50GCS3)	Hewlett-Packard	5890	FID (GC Express)	HP 7673	8015 ERO/DRO	9
Gas Chromatograph (50GCS5)	Hewlett-Packard	5890	Dual ECD	HP 7673	8082 PCBs	15
Gas Chromatograph (50GCS7)	Agilent	7890A	FID	7963	8015 ERO/DRO	<1
Gas Chromatograph (50GCS8)	Agilent	7890A	Dual ECD	7963	8082 PCBs	<1
Gas Chromatograph (50GCV1)	Hewlett-Packard	6890	PID/FID	Centurion	8021/602 MBTEX	4
Gas Chromatograph (50GCV2)	Hewlett-Packard	5890	PID/FID	Archon	8015 GRO	10
Gas Chromatograph (50GCV5)	Hewlett-Packard	5890	PID	Archon	8021/602 MBTEX	9
Gas Chromatograph (50GCV7)	Agilent	6890N	FID	EST 8100	8015 GRO	2
Microwave Extractor (MARS)	CEM	230/60	n/a	n/a	soil extraction	2
Turbo Vap II	Zymark	II	n/a	n/a	sample concentration	3
Speed-Vap III	Horizon	III	n/a	n/a	sample concentration	1
DryVap	Horizon	5000	n/a	n/a	sample concentration	1
Spe-Dex	Horizon	4790	n/a	n/a	water extraction	1
Shaker Table	Eberbach	6010	n/a	n/a	8082 wipes	3
Trace ICP (50ICP1)	TJA	ICAP61E	n/a	n/a	6010/200.7	15
Trace ICP (50ICP2)	Thermo Scientific	ICAP 6500	n/a	n/a	6010/200.7	1
Mercury Analyzer (50HG01)	Perkin Elmer	FIMS	n/a	n/a	7470/7471/245	8
Auto Analyzer (50WTA1)	Lachat	Quick Chem	n/a	n/a	CN,NO3,Cl,Phenol, NH3,TKN	10
COD Reactor	Hach	n/a	n/a	n/a	COD	15
Ignitability Tester	Pensky-Martens	n/a	n/a	n/a	flashpoint	9
Spectrophotometer (50WET1)	Spec 20	Labtronics	n/a	n/a	COD, Sulfide	7
Spectrophotometer (50WET)	Hach	DR5000	n/a	n/a	Sulfate,Cr6+,Fe2+, PO4	2
pH/ISE Meter (50WET4)	Accumet	AR25	n/a	n/a	pH	6
pH/ISE Meter (50WET5)	Accumet	AR25	n/a	n/a	Fluoride, DO	5

ATTACHMENT IV

PASI – INDIANAPOLIS FLOOR PLAN



ATTACHMENT V

PASI – INDIANAPOLIS SOP LIST

Title	SOP Number	Rev	Method	Eff Date
Sample Management	S-IN-C-001	4	none	4/23/2010
Waste Handling and Management	S-IN-S-002	0	none	9/3/2010
Subcontracting Samples	S-IN-C-003	1	none	10/23/2007
Alkalinity	S-IN-I-003	8	SM2320B/310.1	3/3/2008
Waste Management Training Requirements	S-IN-S-003	0	none	9/3/2010
Bottle Preparation	S-IN-C-004	2	none	10/7/2010
Operation of PacePort Customer Feedback Form	S-IN-C-005	0	none	
Volatiles by GC	S-IN-O-006	12	8021B/602	3/29/2010
Chloride	S-IN-I-008	13	SM4500Cl-E/325.2	2/25/2010
Laboratory Documentation	S-IN-Q-009	0	none	3/11/2010
Total Residual Chlorine (TRC)	S-IN-I-010	6	SM4500Cl-G/Hach 8167	3/3/2008
Glassware Cleaning	S-IN-P-011	8	none	3/17/2008
Chemical Oxygen Demand	S-IN-I-012	7	410.4/Hach 8000	2/28/2008
Acidity	S-IN-I-013	8	SM2310B/305.1	3/3/2008
Total Cyanide	S-IN-I-015	10	SM4500CN-CEG/335.4/9010C/9012A	5/25/2010
Data Review, Validation and Approval	S-IN-Q-016	10	none	10/19/2009
ICP Metals	S-IN-I-019	8	6010B	5/15/2009
Diesel Range Organics (DRO)	S-IN-O-020	11	8015C	3/13/2009
Sample Homogenization and Sub-Sampling	S-IN-Q-021	0	none	10/5/2009
Laboratory Housekeeping	S-IN-P-023	6	none	10/23/2007
pH in waters	S-IN-I-024	9	SM4500H+B/150.1	8/19/2010
Fluoride	S-IN-I-027	10	SM4500F-C/340.2	5/6/2009
Volatiles by GC/MS (8260)	S-IN-O-029	15	8260B	3/23/2010
Acid Digestion of Aqueous Samples for ICP Analysis	S-IN-I-030	9	3010	1/19/2010
Acid Digestion of Solide Samples for ICP Analysis	S-IN-I-031	9	3050B	1/11/2010
Hardness	S-IN-I-032	8	SM2340BC/130.2	2/22/2008
Oxidation-Reduction Potential in Soils	S-IN-I-035	5	SM2580B	3/3/2008
Flashpoint	S-IN-I-038	6	1010A	3/3/2008
Mercury in water and soil samples	S-IN-I-040	10	7470A/7471A	3/3/2008
Nitrate/ Nitrite	S-IN-I-042	11	353.2 rev.2	2/27/2008
Ammonia Nitrogen	S-IN-I-043	9	350.1 rev.2	10/23/2007
Metals in air samples	S-IN-I-046	5	NIOSH 7303	10/23/2007
Mercury in air samples	S-IN-I-047	5	NIOSH 6009	9/10/2008
Polychlorinated Biphenyls (PCBs)	S-IN-O-050	10	8082/608	4/1/2010
Total and Respirable Dust	S-IN-I-052	5	NIOSH 0500 & 0600	2/11/2008
Separatory Funnel Extraction	S-IN-O-054	8	3510C	9/30/2009
Internal Chain-of-Custody	S-IN-P-055	6	none	9/9/2008
Lead in air samples	S-IN-I-057	5	40CFR appG/EQ-61189-069	9/10/2008
Laboratory Power Failure	S-IN-P-058	7	none	9/9/2008
Total Phenolics	S-IN-I-059	12	420.4, rev.1	9/10/2010
Phosphorus	S-IN-I-060	9	SM4500P-E/365.2	2/27/2008
Electronic Data Management	S-IN-P-061	7	none	9/9/2008

Title	SOP Number	Rev	Method	Eff Date
TCLP Extraction	S-IN-I-062	9	1311	8/5/2010
Hexavalent Chromium	S-IN-I-063	9	7196A/SM3500Cr-D	2/27/2008
Semi-volatiles by GC/MS	S-IN-O-068	10	8270C	2/27/2008
pH in solids	S-IN-I-069	7	9045D	7/20/2009
Alkaline Digestion for Hexavalent Chromium	S-IN-I-070	7	3060A	9/10/2008
Specific Conductance	S-IN-I-071	6	120.1/SM2510B	8/19/2010
Sulfate- turbidimetric	S-IN-I-073	9	ASTM D516-2/375.4/9038	9/10/2010
Total Sulfide (methylene blue method)	S-IN-I-076	4	SM4500-S2-D/376.2	2/27/2008
Neutral Leachate Extraction	S-IN-I-077	0	ASTM D3987-85	9/20/2010
Total Kjeldahl Nitrogen	S-IN-I-080	7	351.2 rev.2.0	3/11/2010
Measurement of Solids	S-IN-I-084	2	SM2540B,C,D/160 series	2/27/2008
Turbidity (nephelometric method)	S-IN-I-090	7	180.1, rev.2	4/7/2008
Percent Moisture	S-IN-I-094	5	ASTM D2974-87	9/10/2008
Deionized Water Quality testing	S-IN-Q-096	4	none	2/11/2008
Gasoline Range Organics	S-IN-O-109	8	8015C	2/22/2010
Free Liquids	S-IN-I-114	6	9095A	4/7/2008
Ignitability of Solids	S-IN-I-116	5	1030	4/7/2008
Density/ Specific Gravity	S-IN-I-117	5	SM2710F	4/7/2008
Resistivity in soils (AASHTO method)	S-IN-I-118	6	T288-91	3/3/2008
Operation of Waste Disposal Equipment	S-IN-P-119	3	none	3/17/2008
Volatiles by GC/MS (624)	S-IN-O-120	2	624	9/20/2007
Volatiles by GC/MS (524.2)	S-IN-O-121	2	524.2, rev. 4.1	4/9/2008
TSP and PM-10 analyses	S-IN-I-123	3	none	9/10/2008
QC Limit Generation and Implementation	S-IN-Q-126	1	none	4/7/2008
Laboratory Spreadsheet Validation	IN-Q-127	1	none	9/10/2008
Ferrous Iron	S-IN-I-128	1	SM3500Fe-D/Hach 8146	2/27/2008
Extraction for Free Cyanide	S-IN-I-129	1	9014	9/10/2008
Microwave Extraction	S-IN-O-130	2	3546	5/15/2009
ICP Metals (200.7)	S-IN-I-131	0	200.7, rev.4.4	2/28/2008
Mercury in waters (245.1)	S-IN-I-132	1	245.1, rev.3	2/27/2008
Semi-volatiles by GC/MS (SIM)	S-IN-O-133	1	8270 SIM	4/7/2008
Alcohols/Glycols by GC (modified 8015)	S-IN-O-134	2	8015 mod	8/19/2010
Chemical Oxygen Demand **(Speedway/Marathon only)**	S-IN-I-149	0	410.4/Hach 8000	2/28/2008
Sulfuric Acid Clean-up for PCBs	S-IN-O-150	3	3665	9/30/2009
Sulfur Clean-up for PCBs Copper Method	S-IN-O-151	3	3660B	9/30/2009
Receipt of Lab Supplies	S-IN-P-152	2	none	7/27/2009
Training Procedures	S-IN-Q-153	0	none	10/23/2007
Audits and Inspections	S-IN-Q-154	0	none	10/23/2007
Manual Integration	S-IN-Q-156	1	none	7/20/2009
Support Equipment	S-IN-Q-157	3	none	4/1/2010
EPIC Pro: Acode Validation	S-IN-Q-158	0	none	2/11/2008
EPIC Pro: Acode Addition/Modification	S-IN-Q-159	0	none	3/17/2008
n-Hexane Extractable Material	S-IN-O-160	0	1664A	3/13/2009
Extraction of Wipes for PCB Analysis	S-IN-O-161	1	8082A	4/1/2010
Synthetic Precipitation Leaching Procedure (SPLP)	S-IN-I-162	0	1312	9/20/2010

Ohio VAP-specific SOPs

Title	SOP Number	Rev	Method	Eff Date
Data Review, Validation and Approval **(Ohio VAP only)**	S-IN-VAP-Q-016	0	none	8/3/2010
ICP Metals **(Ohio VAP only)**	S-IN-VAP-I-019	4	6010B	9/10/2010
Diesel Range Organics (DRO) **(Ohio VAP only)**	S-IN-VAP-O-020	9	8015B	9/24/2010
Volatiles by GC/MS (8260) **(Ohio VAP only)**	S-IN-VAP-O-029	1	8260A/B, 5030A/B, 5035A	9/24/2010
Acid Digestion of Aqueous Samples for ICP Analysis **(Ohio VAP only)**	S-IN-VAP-I-030	8	3010A	9/10/2010
Acid Digestion of Solid Samples for ICP Analysis **(Ohio VAP only)**	S-IN-VAP-I-031	9	3050B	9/24/2010
Mercury **(Ohio VAP only)**	S-IN-VAP-I-040	1	7470A/7471A	9/23/2010
Ammonia Nitrogen **(Ohio VAP only)**	S-IN-VAP-I-043	10	350.1	9/24/2010
Polychlorinated Biphenyls (PCBs) **(Ohio VAP only)**	S-IN-VAP-O-050	1	8082	9/24/2010
Separatory Funnel Extraction **(Ohio VAP only)**	S-IN-VAP-O-054	1	3510C	7/8/2010
Hexavalent Chromium **(Ohio VAP only)**	S-IN-VAP-063	1	7196A	9/24/2010
Semi-volatiles by GC/MS **(Ohio VAP only)**	S-IN-VAP-O-068	10	8270C	9/24/2010
Alkaline Digestion of Solids for Hexavalent Chromium **(Ohio VAP only)**	S-IN-VAP-I-070	0	3060A	8/3/2010
Gasoline Range Organics **(Ohio VAP only)**	S-IN-VAP-O-124	1	8015A/B	9/24/2010
Microwave Extraction **(Ohio VAP only)**	S-IN-VAP-O-130	1	3546	7/8/2010
Semi-volatiles by GC/MS (SIM) **(Ohio VAP only)**	S-IN-VAP-O-133	1	8270C SIM	9/24/2010
Manual Integration **(Ohio VAP only)**	S-IN-VAP-Q-156	0	none	6/8/2010

Pace 3P Standard Operating Procedure (ALL-SOP) Summary

Title	SOP Number	Rev	Method	Eff Date
Bottle Order Database	S-ALL-C-002	1	none	
Operation of Paceport Customer Feedback Form	S-ALL-C-005	1	none	
Review of Analytical Requests	S-ALL-C-006	0	none	10/7/2010
System Security and Integrity	S-ALL-IT-001	2	none	
Server Back-up	S-ALL-IT-002	2	none	
Preparation of SOPs	S-ALL-Q-001	9	none	
Document Management	S-ALL-Q-002	2	none	
Document Numbering	S-ALL-Q-003	4	none	
Method and Instrument Detection Limit Studies	S-ALL-Q-004	5	none	3/31/2010
EPIC Pro: Acode Validation	S-ALL-Q-007	2	none	na
EPIC Pro: Acode Addition/Modification	S-ALL-Q-008	1	none	na
Laboratory Documentation	S-ALL-Q-009	2	none	na
PE/PT Program	S-ALL-Q-010	3	none	3/31/2010
Audits and Inspections	S-ALL-Q-011	3	none	na
Corrective Action/ Preventative Action Process	S-ALL-Q-012	2	none	5/14/2010
Support Equipment	S-ALL-Q-013	1	none	
Quality System Review	S-ALL-Q-014	1	none	
Manual Integration	S-ALL-Q-016	3	none	na
Monitoring Storage Units	S-ALL-Q-018	2	none	na
Orientation and Training Procedures	S-ALL-Q-020	3	none	
Sub-sampling (Sample Homogenization)	S-ALL-Q-021	3	none	na
3P Program: Continuous Process Improvement	S-ALL-Q-022	2	none	
Standard and Reagent Management and Traceability	S-ALL-Q-025	3	none	3/31/2010
Software Validation	S-ALL-Q-026	1	none	
Evaluation and Qualification of Vendors	S-ALL-Q-027	1	none	
Use and Operation of Lab Track System	S-ALL-Q-028	1	none	5/24/2010
MintMiner Data File Review	S-ALL-Q-029	1	none	3/31/2010
Operation of Data Checker for EPIC Pro	S-ALL-Q-030	2	none	
Hazard Assessment	S-ALL-S-001	2	none	3/23/2010

ATTACHMENT VI

PASI – INDIANAPOLIS CERTIFICATION LIST

Accrediting Authority	Program Category	Accrediting Agency	Certification #	Expiration Date
Illinois (NELAC)	Hazardous Waste	IL-EPA	100418	10/12/2011
Illinois (NELAC)	Non-Potable Water	IL-EPA	100418	10/12/2011
Indiana	Drinking Water VOA	ISDH	C-49-06	05/09/11
Kansas	Hazardous Waste	KDHE	E-10247	04/30/2011
Kansas	Non-Potable Water	KDHE	E-10247	04/30/2011
Kentucky	UST	KDEP	42	01/13/2011
Louisiana	Non-Potable Water	LA-DEQ	04076	06/30/2011
Louisiana	Solid Chemical Mat.	LA-DEQ	07076	06/30/2011
Ohio VAP	Hazardous Waste	OH-EPA	CL-0065	04/27/2012
Ohio VAP	Non-Potable Water	OH-EPA	CL-0065	04/27/2012
Pennsylvania	Solid & Chemical Mat.	PA-DEP	68-00791	07/31/2011
Pennsylvania	Non-Potable Water	PA-DEP	68-00791	07/31/2011
West Virginia	Hazardous Waste	WV-DEP	330	10/31/2010
West Virginia	Non-Potable Water	WV-DEP	330	10/31/2010
USDA	Foreign Soil	USDA	P330-10-00128	04/15/2013

ATTACHMENT VII

PASI – CHAIN OF CUSTODY

CHAIN-OF-CUSTODY / Analytical Request Document

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

Pace Analytical™ www.pacelabs.com

Section A **Required** Client Information:		Section B **Required** Project Information:	Section C Invoice Information:
Company:		Report To:	Attention:
Address:		Copy To:	Company Name:
			Address:
Email To:		Purchase Order No.:	Pace Quote Reference:
Phone:	Fax:	Project Name:	Pace Project Manager:
Requested Due Date/TAT:		Project Number:	Pace Profile #:

Page: of

REGULATORY AGENCY

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

Site Location
STATE: ____

Requested Analysis Filtered (Y/N)

Section D
Required Client Information

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

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

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	Preservatives – Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	↓ Analysis Test ↓ (Y/N)													Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1																																
2																																
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10																																
11																																
12																																

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
							Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER:

SIGNATURE of SAMPLER: **DATE Signed (MM/DD/YY):**

ATTACHMENT VIII
METHOD HOLD TIME, CONTAINER AND PRESERVATION GUIDE

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
2, 3, 7, 8-TCDD	1613B	Soil	8oz Glass	None	90/40 Days
2, 3, 7, 8-TCDD	1613B	Water	1L Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	90/40 Days
2, 3, 7, 8-TCDD	8290	Water	1L Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	30/45 Days
Acidity	SM2310B	Water	Plastic/Glass	$\leq 6^oC$	14 Days
Alkalinity	SM2320B/310.2	Water	Plastic/Glass	$\leq 6^oC$	14 Days
Alpha Emitting Radium Isotopes	9315/903.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Anions by IC, including Br, Cl, F, NO_2, NO_3, SO_4	300.0/300.1/ SM4110B	Water	Plastic/Glass	$\leq 6^oC$	Br, Cl, F, SO_4 (28 Days) NO_2, NO_3 (48 Hours)
Anions by IC, including Br, Cl, F, NO_2, NO_3, SO_4	300.0/9056	Soil	Plastic/Glass	$\leq 6^oC$	Br, Cl, F, SO_4 (28 Days) NO_2, NO_3 (48 Hours)
Aromatic and Halogenated Volatiles	8021	Soil	5035 vial kit	See 5035 note*	14 days
Aromatic and Halogenated Volatiles	601/602/8021	Water	40mL vials	pH<2 HCl; $\leq 6^oC$; $Na_2S_2O_3$ if Cl present	14 Days
Acid Volatile Sulfide	Draft EPA 1629	Soil	8oz Glass	$\leq 6^oC$	14 Days
Bacteria, Total Plate Count	SM9221D	Water	Plastic/WK	$\leq 6^oC$; $Na_2S_2O_3$	24 Hours
Base/Neutrals and Acids	8270	Soil	8oz Glass	$\leq 6^oC$	14/40 Days
Base/Neutrals and Acids	625/8270	Water	1L Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Base/Neutrals, Acids & Pesticides	525.1/525.2	Water	1L Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/30 Days
BOD/cBOD	SM5210B	Water	Plastic/Glass	$\leq 6^oC$	48 hours
BTEX/Total Hydrocarbons	TO-3	Air	Summa Canister	None	14 Days
BTEX/Total Hydrocarbons	TO-3	Air	Tedlar Bag	None	48 Hours
Cation/Anion Balance	SM1030E	Water	Plastic/Glass	None	None
Chloride	SM4500Cl/9250/ 9251/9252	Water	Plastic/Glass	None	28 Days
Chlorinated Herbicides	8151	Soil	8oz Glass Jar	$\leq 6^oC$	7/40 Days
Chlorinated Herbicides	8151	Water	1L Amber	$\leq 6^oC$;	7/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			Glass	$Na_2S_2O_3$ if Cl present	
Chlorinated Herbicides	515.1	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	14/28 Days
Chorine, Residual	SM4500Cl	Water	Plastic/Glass	None	15 minutes
COD	SM5220C/ 410.3/410.4	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Color	SM2120B,C,E	Water	Plastic/Glass	$\leq 6^oC$	48 Hours
Condensable Particulate Emissions	EPA 202	Air	Solutions	None	6 Months
Cyanide, Reactive	SW846 chap.7	Water	Plastic/Glass	None	28 Days
Cyanide, Total and Amenable	SM4500CN/9010/ 9012/335.4	Water		pH>12 NaOH; $\leq 6^oC$; ascorbic acid if Cl present	14 Days, 24 Hours if Sulfide present
Diesel Range Organics- TPH DRO	8015	Soil	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Diesel Range Organics- TPH DRO	8015	Water	1L Glass	$\leq 6^oC$	7/40 Days
Diesel Range Organics (WI)	WI MOD DRO	Soil	8oz Glass Jar	$\leq 6^oC$	10/47 Days
Diesel Range Organics (WI)	WI MOD DRO	Water	1L Glass	$\leq 6^oC$	14/40 Days
Dioxins & Furans	TO-9	Air	PUF	None	30/45 Days
EDB & DBCP	504.1/8011	Water	40mL vials	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	14 Days
Explosives	8330/8332	Water	1L Glass	$\leq 6^oC$	7/40 Days
Explosives	8330/8332	Soil	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Fecal Coliform	SM9222D	Water	100mL Plastic	$\leq 6^oC$	6 Hours
Fecal Coliform	SM9222D	Soil	100mL Plastic	$\leq 6^oC$	6 Hours
Ferrous Iron	SN3500Fe-D	Water	Glass	None	Immediate
Flashpoint/Ignitability	1010/1030	Water	Plastic/Glass	None	28 Days
Fluoride	SM4500Fl-C,D	Water	Plastic	None	28 Days
Gamma Emitting Radionuclides	901.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Gas Range Organics	8015	Water	40mL vials	pH<2 HCl	14 Days
Gasoline Range Organics	8015	Soil	5035 vial kit	See 5035 note*	14 days
Gross Alpha (NJ 48Hr Method)	NJAC 7:18-6	Water	Plastic/Glass	pH<2 HNO_3	48 Hrs
Gross Alpha and Gross Beta	9310/900.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Haloacetic Acids	552.1/552.2	Water	40mL Amber vials	NH_4Cl; $\leq 6^oC$	14/7 Days
Hardness, Total ($CaCO_3$)	SM2340B,C/130.1	Water	Plastic/Glass	pH<2 HNO_3	6 Months
Heterotrophic Plate Count (MPC)	EPA 9215B	Water	100mL Plastic	$\leq 6^oC$	24 Hours
Hexavalent Chromium	7196/218.6/ SM3500Cr	Water	Plastic/Glass	$\leq 6^oC$	24 Hours
Hydrogen Halide & Halogen	EPA 26	Air	Solutions	None	6 Months

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Emissions					
Lead Emissions	EPA 12	Air	Filter/Solutions	None	6 Months
Low Level Mercury	1631	Water	Glass	BrCl	90 days (if preserved and oxidized)
Mercury	7471	Soil	8oz Glass Jar	$\leq 6^oC$	28 days
Mercury	7470/245.1/245.2	Water	Plastic/Glass	pH<2 HNO_3	28 Days
Metals	7300/7303	Air	Filters	None	6 Months
Metals (and other ICP elements)	6010	Soil	8oz Glass Jar	None	6 months
Metals (and other ICP elements)	6010/6020/200.7/ 200.8	Water	Plastic/Glass	pH<2 HNO_3	6 Months
Methane, Ethane, Ethene	EPA Mod 8015	Water	40mL vials	HCl	14 Days
Methane, Ethane, Ethene	RSK-175	Water	40mL vials	HCl	14 Days
Methane, Ethane, Ethene	EPA 3C	Air	Summa Canister	None	14 Days
Methane, Ethane, Ethene	EPA 3C	Air	Tedlar Bag	None	48 Hours
Methanol, Ethanol	EPA 8015	Water	40mL vials	$\leq 6^oC$	14 Days
Methanol, Ethanol	EPA 8015	Soil	2oz Glass	$\leq 6^oC$	14 Days
Nitrogen, Ammonia	SM4500NH3/350.1	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Nitrogen, Kjeldahl	SM4500-Norg; 351.1/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Nitrogen, Nitrate	SM4500-NO3/ 352.1	Water	Plastic/Glass	$\leq 6^oC$	48 Hours
Nitrogen, Nitrate & Nitrite	SM4500-NO3/ 353.2	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Nitrogen, Nitrite	SM4500-NO2/ 353.2	Water	Plastic/Glass	$\leq 6^oC$	48 Hours
Nitrogen, Organic	SM4500-Norg/ 351.2	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Non-Methane Organics	EPA 25C	Air	Summa Canister	None	14 Days
Non-Methane Organics	EPA 25C	Air	Tedlar Bag	None	48 Hours
Odor	SM2150B	Water	Glass	$\leq 6^oC$	24 Hours
Oil and Grease/HEM	1664A/SM5520B/ 9070	Water	Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Organochlorine Pesticides & PCBs	TO-4	Air	PUF	None	7/40 Days
Organochlorine Pesticides & PCBs	8081/8082/608	Water	1L Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Organochlorine Pesticides & PCBs	8081/8082	Soil	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Organophosphorous Pesticides	8141	Soil	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Organophosphorous Pesticides	8141	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Oxygen, Dissolved (Probe)	SM4500-O	Water	Glass	None	15 minutes
Paint Filter Liquid Test	9095	Water	Plastic/Glass	None	N/A

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Particulates	PM-10	Air	Filters	None	6 Months
Permanent Gases	EPA 3C	Air	Summa Canister	None	14 Days
Permanent Gases	EPA 3C	Air	Tedlar Bag	None	48 Hours
pH	SM4500H+B/9040/ 9041/150.2	Water	Plastic/Glass	None	15 minutes
Phenol, Total	420.1/420.4/9065/ 9066	Water	Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Phosphorus, Orthophosphate	SM4500P/365.1/365.3	Water	Plastic	Filter; $\leq 6^oC$	Filter within 15 minutes, Analyze within 48 Hours
Phosphorus, Total	SM4500P/ 365.1/365.3/365.4	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Phosphorus, Total	EPA 365.4	Soil	Plastic/Glass	$\leq 6^oC$	28 Days
Polynuclear Aromatic Hydrocarbons	TO-13	Air	PUF	None	7/40 Days
Polynuclear Aromatic Hydrocarbons	8270 SIM	Soil	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Polynuclear Aromatic Hydrocarbons	8270 SIM	Water	1L Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Radioactive Strontium	905.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-226 Radon Emanation Technique	903.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228	9320/904.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Silica, Dissolved	SM4500Si-D	Water	Plastic	$\leq 6^oC$	28 Days
Solids, Settleable	SM2540F	Water	Glass	$\leq 6^oC$	48 Hours
Solids, Total	SM2540B	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total (FOC)	ASTM D2974	Soil	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Dissolved	SM2540C	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Suspended	SM2540D	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Volatile	SM2540E	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Specific Conductance	SM2510B/9050/120.1	Water	Plastic/Glass	$\leq 6^oC$	28 Days
Stationary Source Dioxins & Furans	EPA 23	Air	XAD Trap	None	30/45 Days
Stationary Source Mercury	EPA 101	Air	Filters	None	6 Months, 28 Days for Hg
Stationary Source Metals	EPA 29	Air	Filters	None	6 Months, 28 Days for Hg
Stationary Source PM10	EPA 201A	Air	Filters	None	6 Months
Stationary Source Particulates	EPA 5	Air	Filter/Solutions	None	6 Months
Sulfate	SM4500SO4/9036/ 9038/375.2/ASTMD516	Water	Plastic/Glass	$\leq 6^oC$	28 Days
Sulfide, Reactive	SW-846 Chap.7	Water	Plastic/Glass	None	28 Days
Sulfide, Total	SM4500S/9030	Water	Plastic/Glass	pH>9 NaOH; ZnOAc; $\leq 6^oC$	7 Days

Appendix F-2

AECOM Field Standard Operating Procedures

AECOM

Standard Operating Procedure

Water Level Measurements

Procedure Number: 9903-FSP-SOP-09

Revision No.: 0

Revision Date: October 2010

________________________________ Date: ________________________________
SOP Author

________________________________ Date: ________________________________
Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

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Contents

1.0 Scope and Applicability

1.1 This Standard Operating Procedure (SOP) defines the methods to be used for measuring the depth to groundwater and total depth of groundwater monitoring wells and piezometers. Similar procedures can also be used to measure the depth to water in other structures such as catch basins or cisterns or in surface water bodies from fixed structures such as bridges, culverts, or piers.

1.2 Water level and well depth measurements collected from monitoring wells or piezometers may be used for the following purposes, among others:

- To evaluate the well condition (potential silt accumulation, height of water column, etc.);
- To establish sampling requirements, such as purge volumes and drawdown during purging;
- To calculate the horizontal hydraulic gradient and the direction of groundwater flow;
- To calculate the vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane);
- To evaluate the effects of manmade and natural stresses on the groundwater system; and
- To calculate other important hydrogeologic characteristics (e.g., measuring drawdown during slug tests or aquifer pumping tests).

This information, when combined with other location-specific information, is important in understanding the current distribution of constituents in groundwater and their potential for migration in the future. Hydrogeologic characterization is important not only in evaluating potentially contaminated groundwater but also in evaluating non-contaminated groundwater resources.

1.3 Some wells may contain a light non-aqueous phase liquid (LNAPL) floating on the water surface. The procedures outlined in this SOP may be used to measure water levels in such wells, but the results may not be representative of the hydraulic head/potentiometric level.

1.4 There are other methods for measuring water depths than those described in this SOP, for example, a weighted tape with or without a sounding device ("plopper"), pressure transducers, air line pressure, strip recorders, etc. This SOP addresses the methods in most common and regular use.

1.5 This SOP is to be utilized to conduct the work identified in the title of this SOP. In the event the Project Manager or Project Team determines that the protocols and procedures listed in this SOP are not applicable to the project, there is the option to either adapt this SOP or to develop a site-specific SOP to more closely match the requirements of the project.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Interferences

3.1 Potential interferences could result in inaccurate readings if the sensor on the water level meter is wet or dirty, or if the cable cannot be kept vertically upright (for example, from a well that is not plumb or from a bridge in windy conditions). Care shall be taken to keep the probe clean, and to take appropriate measures to reduce these interferences when measuring water levels. The probe may also be shaken to remove water or other fluids that may adhere to the probe. If there is any concern that a particular reading may not be accurate, this shall be noted in the field log book.

3.2 If LNAPL is present in a well, the measured depth to water may not be representative of the hydraulic head/potentiometric level. If the LNAPL thickness and specific gravity are known, an accurate hydraulic head can be calculated.

3.3 Some water level meters (especially oil/water interface probes) may rely on optical technology for readings. In these cases, the readings may be influenced by the presence of light. While this is not an issue in wells, it may be at surface water bodies.

3.4 The measured depth to water is not always representative of the hydraulic head in the aquifer. Interferences may include barometric pressure effects, timing during tidal cycles, well construction details, confined/artesian aquifers, well efficiency, etc. Where such influences may be important, the project-specific work plan should specify any corrective measures or additional data to be collected. Interpretation and use of water level data should be performed by a trained specialist.

4.0 Equipment and Materials

4.1 Electronic Water Level Meter - Electronic water level meters consist of a spool of small-diameter cable (or tape) with a weighted probe attached to the end. The cable (or tape) is marked with measurement increments in feet (ft) or meters (m) (accurate to 0.01 ft/0.01 m), with the zero point being the sensor of the probe. When the probe comes in contact with the water, an electrical circuit is closed, and a light and/or buzzer within the spool will signal the contact. The cable must be of sufficient length the reach to the expected depth of the water to be measured. The probe shall be tested (using water containing dissolved ions) at the start of the field program to ensure proper operation.

4.2 An oil/water interface probe may be used to measure water depths. However, in some cases, there may be increased risk of cross-contamination using a probe that is regularly placed in separate-phase liquids. Where such risks are considered significant, project-specific requirements will specify that oil-water interface probes are not to be used in wells where no separate-phase liquids are expected.

Other materials that may be required:

- Health and safety supplies (as required by the HASP)
- Equipment decontamination materials, including absorbent pads if appropriate
- Plastic sheeting or bucket for resting instrument off the ground
- Water level field form (if applicable)
- Well construction records
- Approved plans (e.g., Field Sampling Plan, Quality Assurance Plan, HASP)
- Field project logbook/waterproof pen
- Appropriate hand tools and keys to access monitoring wells

5.0 Procedures

5.1 Measurements will involve measuring the depth to water and/or total well depth to the nearest 0.01 ft/0.01 m using an electronic water level meter. The depths within wells will be measured from the top of casing (typically the inner casing) at the surveyed elevation point. This reference point should be marked so that readings are consistently taken from the same reference point. Depths to surface water may be similarly measured from a marked reference point on the fixed structure (e.g., bridge, culvert, pier, wharf) passing over or bordering the surface water body.

5.2 General preparation

5.2.1 Well records review: Well completion diagrams should be reviewed to determine well construction characteristics, including the location of the reference point and the total depth of the well. Historic static water level measurements and survey information may also be reviewed.

5.2.2 Well access: Many wells may be locked for security reasons. The necessary procedures and equipment to access the wellhead shall be identified prior to entering the site.

5.2.3 Equipment: There are many different water level meters available. Field personnel should make sure the appropriate equipment is used based on well construction details (e.g., well diameter, anticipated depth to water). The specific equipment to be used should be inspected. Field personnel should be sure the equipment is in proper working order, and the measurement increment marks are legible. The type of power supply (e.g., type of batteries) should be determined so that an appropriate back-up supply can be obtained if needed. Sometimes water level meters may be repaired by removing a length of cable near the sensor and re-splicing the cable to the sensor. If this kind of repair has taken place, the measurement markings on the cable are no longer accurate. This condition should be observed and noted, and if appropriate, a replacement water level meter may be obtained as an alternative to correcting the water level measurement for the length of the splice.

5.2.4 Calibration: Manufacturer's instructions, if any, for calibrating or maintaining the accuracy of the instrument shall be followed. If there are project-specific requirements for calibration, these shall also be implemented as outlined in project-specific plans.

5.2.5 Equipment decontamination: All down-hole equipment should be decontaminated prior to and after use and between well locations in accordance with project-specific requirements. Note that some water level probes may be made of materials that are incompatible with certain decontamination solvents.

5.2.6 Order of measurement: For some projects, there may be a specific order in which measurements are to be collected, for example, from the least to most contaminated wells. Any such requirements will be specified in the project-specific plans.

5.2.7 Opening the well: Prior to accessing the well, the wellhead should be cleared of debris and/or standing water. For example, it is common to find standing water in flush mount wellheads that, if not removed, will enter the monitoring well, potentially causing inaccurate water level measurements and/or contamination of the groundwater. Nothing from the ground surface should be allowed to enter the well. Once the wellhead is clear, open the well to obtain the measurements. In some cases, it may be necessary to allow the water level to equilibrate prior to measurement (e.g., wells with fully submerged screened intervals).

5.3 Measurement procedures

5.3.1 At each location (well, piezometer, bridge/culvert, pier/wharf, etc.), determine the location of the surveyed elevation mark. For wells, general markings may include either a notch in the riser pipe or a permanent ink mark on the riser pipe. Some projects may specify a consistent reference point for all wells, for example, the highest point on the riser or the northernmost point. For monitoring surface water levels, there may be a painted mark on an existing structure or the reference point must be known if not marked.

5.3.2 If the reference point is not marked, a point may be selected and clearly and permanently marked to be used for future measurements. If this is done, the project manager must be notified to arrange for the elevation of the new reference point to be surveyed.

5.3.3 To obtain a water level measurement, lower the probe of the water level meter down into the water in the well until the audible sound of the unit is detected or the light on an electronic sounder illuminates. In wells, the probe shall be lowered slowly into the well to avoid disruption of formation water and creation of turbulent water within the well. At this time, the precise measurement should be determined (to the nearest 0.01 ft/0.01 m) by repeatedly raising and lowering the tape to converge on the exact measurement. Obtain the reading from the stadia-marked cable where it crosses the surveyed reference point. If the cable is not marked to the nearest 0.01 ft/0.01 m, a manual rule may be used to interpolate between marked measurements.

5.3.4 Record the water level measurement as well as the location identification number, measuring point (surveyed elevation point), date, time, and weather conditions in the field logbook and/or field form. Any problems with the condition of the well should be noted so that appropriate maintenance can be performed.

5.3.5 To measure the total depth of a well, lower the probe (turn down signal as appropriate) slowly to the bottom of the well. For deep wells or wells with a soft or silty base, the depth may be difficult to determine. It may be helpful to lower the probe until there is slack in the tape, and gently pull up until it feels as if there is a weight at the end of the tape. Obtain the depth reading (to the nearest 0.01 ft/0.01 m) from the cable where it crosses the surveyed reference point. If the cable is not marked to the nearest 0.01 ft/0.01 m, a manual rule may be used to interpolate between marked measurements.

5.3.6 Record the total well depth in the field logbook and/or field form.

5.3.7 The meter will be decontaminated in accordance with 9903-FSP-SOP-13. If the probe was in contact with separate-phase liquids, the potential for cross-contamination is greater, so appropriate care should be taken during decontamination, as specified in project-specific requirements. It is important to avoid placing the measuring tape and probe directly on the ground surface (to minimize potential cross-contamination) or allowing the cable to become kinked (which affects the accuracy of the measured depths).

5.4 Special Conditions

5.4.1 Wells containing pumps or other equipment. It may be difficult to obtain accurate water level depths in wells where down-hole equipment is present. There may not be sufficient space within the well for the water level meter, or the meter cable may become bound up in the tubing, cables, or other equipment in the well. It is preferable to remove down-hole equipment when feasible. If removal of the equipment is not feasible and there is a reasonable chance of getting the meter caught in the well and not being able to remove it, it may be preferable to avoid collecting water level data.

5.4.2 Drinking water wells. The water level meter represents a potential source of surface contamination when introduced into drinking water wells, particularly for bacteriological contamination. If it is necessary to measure water level depths in drinking water wells using the procedures in this SOP, appropriate disinfection procedures should be performed.

6.0 Quality Assurance / Quality Control

6.1 Field personnel will follow site-specific quality assurance guidelines. Where measured depths are not consistent with well records or previously measurements, the depths should be re-measured, verified, and documented in the field records.

6.2 Field duplicates of the depth-to-water measurements will be obtained if required by and at the frequency specified in project-specific requirements. To collect a field duplicate measurement, the water level probe will be fully withdrawn from the well, then re-lowered to obtain a second reading of the depth to water. No more than a few minutes should elapse between the two measurements. Field duplicates will not be obtained if water levels are changing rapidly, for example, during pumping tests.

6.3 Manufacturer's instructions, if any, for calibrating or maintaining the accuracy of the instrument shall be followed.

7.0 Data and Records Management

7.1 All field information will be recorded in the field logbook or on a field collection form by field personnel. Recording of field data will follow the guidance presented in 9903-FSP-SOP-01, Recording of Field Data.

7.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

7.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

8.0 Personnel Qualifications and Training

8.1 Qualifications and training

8.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

8.1.2 Collecting water level measurements is a relatively simple procedure requiring minimal training and a relatively small amount of equipment. It is recommended that the collection of water level measurements be initially supervised by more experienced personnel.

8.1.3 Field personnel must be health and safety trained as required by the project conditions and local/national standards.

8.2 Responsibilities

8.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

8.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

8.2.3 Field personnel are responsible for the proper use, maintenance, and decontamination of all equipment used for obtaining water level measurements, as well as proper documentation in the field logbook or field forms (as appropriate).

9.0 References

American Society for Testing Materials. 1993. ASTM Standard D4750, Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).

Driscoll, Fletcher G. 1986. Groundwater and Wells. St. Paul Minnesota: The Johnson Division.

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

10.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

Standard Operating Procedure

Groundwater Sample Acquisition

Procedure Number: 9903-FSP-SOP-11

Revision No.: 0

Revision Date: October 2010

______________________________ Date: ______________________________

SOP Author

______________________________ Date: ______________________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

Initials: ________ Date: ________

Standard Operating Procedure

Groundwater Sample Acquisition

Contents

Standard Operating Procedure
Groundwater Sample Acquisition

1.0 Scope and Applicability

The purpose of this guideline is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

This guideline provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustment in methods.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this POP, including both potential physical and chemical hazards, will be addressed in the site specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the ENSR Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Equipment and Materials

The following list of equipment will be used to determine the depth to water, purged volume, and analytical parameters. Ideally, sample withdrawal equipment should be completely inert, economical, easily cleaned, sterilized, and reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

3.1 Sampling/Purging Equipment

- Shallow-well pumps: Centrifugal, Packer Pumps, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing), as applicable.
- Deep-well pumps: Submersible pump and electrical power generating unit, bladder pump with compressed air source, or air-lift apparatus, as applicable.
- Low flow submersible bladder pump or peristaltic sampling pump
- Teflon and polyethylene tubing; tubing type shall be selected based on specific site requirements and must be chemically inert to the groundwater being sampled.
- Other sampling equipment: Bailers, Teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with tripod-pulley assembly (if necessary).

- Water level measurement equipment

3.2 Field Analytical Parameter Measurement

- In-line water quality meter (e.g., flow-through cell)
- Water quality meter with individual temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, salinity, and oxidation reduction potential (ORP) probes
- Turbidity meter

3.3 Supporting Documents

- Project specific Work Plan
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP Field data sheets and log book

3.4 Decontamination Equipment

- Distilled water
- Isopropanol (laboratory grade)
- Spray bottles for decontamination solutions Chemical free paper towels

3.5 Sample Collection

- Preservation solutions (if necessary)
- Sample containers
- Coolers

3.6 Peristaltic Pump Sample Collection

- Generator and extension cord
- Battery packs

3.7 Bladder Pump Sample Collection

- Dedicated bladders Pump controller box
- Nitrogen (air supply) Detergent/Alconox
- Nitric or hydrochloric acid (laboratory grade)
- Cleaning brushes

3.8 Miscellaneous

- Disposable gloves
- Tubing cutters
- Plastic sheeting
- PPE

- Buckets and intermediate containers

4.0 Procedures

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain largely isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

- All monitoring wells shall be pumped or bailed prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.
- Wells that can be pumped or bailed to dryness with the sampling equipment being used shall be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of at least three well volumes of water is preferred; otherwise, a sample will be taken when enough water is available to fill the sample containers.

Stratification of contaminants may exist in the aquifer formation. This is from concentration gradients due to dispersion and diffusion processes in a homogeneous layer, and from separation of flow streams by physical division (for example, around clay lenses) or by contrasts in permeability (for example, between a layer of silty, fine sand and a layer of medium sand).

Purging rates and volumes for non-production wells during sampling development should be moderate; pumping rates for production wells should be maintained at the rate normal for that well. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, thus result in the collection of a non-representative sample. Water produced during purging should be collected, stored or treated and discharged as allowed. Disposition of purge water is usually site-specific and must be addressed in the Sampling and Analysis Plan.

4.1 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with EPA regulations for the appropriate contaminants and to the specific Quality Assurance Project Plan.

4.2 Calculations of Well Volume for Purging

To insure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well pipe or casing. The volume can be easily calculated by the following method. Calculations shall be entered in the field log book:

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine inside diameter of well or casing (D).
- Measure and record static water level (DW – depth to water below ground level or top of casing reference point) to the nearest 0.01-foot, using one of the methods described in Section 5.1 of SOP F202.
- Determine the depth of the well (TD) to the nearest 0.01-foot by sounding a clean, decontaminated weighted tape measure, referenced to the top of PVC casing or ground surface.
- Calculate the volume of water in the casing:

$$VW \; \frac{\pi D2}{4} \; (TD - DW)$$

$$Vgal = VW \times 7.48 \text{ gallons/ft3}$$

Where:

VW = Volume of water standing in well in cubic feet (i.e., one well volume)

π = pi, 3.14

D = Inside diameter of well in feet

TD = Total depth of well in feet (below ground surface or top of casing)

DW = Depth to water in feet (below ground surface or top of casing)

- Calculate the minimum number of gallons to be evacuated before sampling. (Note: V_{purge} should be rounded to the next highest whole gallon. For example, 7.2 gallons should be rounded to 8 gallons.)

$$V_{purge} = V_{gal} \text{ (\# Well Vol.)}$$

Where:

V_{gal} = Volume of water in well in gallons

V_{purge} = Volume of water to be purged from well in gallons

Well Vol. = Number of well volumes of water to be purged from the well (typically three to five)

Table 5-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameters.

TABLE 5-1 – WELL VOLUMES

Diameter of Casing or Hole (in.)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth
1	0.041	0.0055
2	0.163	0.0218
4	0.653	0.0873
6	1.469	0.1963
8	2.611	0.3491
10	4.080	0.5454

4.3 Evacuation of Static Water (Purging)

The amount of purging a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from a wide area. Generally, three to five well volumes are considered effective for purging a well.

An alternative method of purging a well, and one accepted in EPA Regions I and IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, turbidit, and water temperature until the values stabilize. Values are considered to have stabilized when deviation is less than 10 percent of the mean. The well is considered properly purged when values have stabilized.

If a well is dewatered before the required volume is purged, the sample should be collected from the well once as a sufficient volume of water has entered the well. In order to avoid stagnation, the well should not be allowed to fully recharge before the sample is collected. The field parameters (pH, conductance, and temperature) should be recorded when the well was dewatered.

The Project Manager shall define the objectives of the groundwater sampling program in the Sampling and Analysis Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

4.3.1 Evacuation Devices

The following discussion is limited to those devices which are commonly used at hazardous waste sites. Note that all of these techniques involve equipment which is portable and readily available.

Bailers – Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as if more useful and favored, with a ball check-valve at the bottom. An inert line (e.g., Teflon-coated) is used to lower the bailer and retrieve the sample.

Advantages of the bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Inexpensive.
- Minimal outgassing of volatile organics while the sample is in the bailer.
- Relatively easy to decontaminate and use.

Limitations on the use of bailers include the following:

- Limited volume of sample.
- Time consuming to remove stagnant water using a bailer.
- Collection and transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.
- Unable to collect depth-discrete sample.

Suction Pumps – There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (generally not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross-contamination. The pitcher pump is a common farm hand-pump.

Advantages of suction pumps include:

- Few limitations with regards to well diameter
- Inexpensive
- Portable
- Readily available
- Tubing can be dedicated or easily decontaminated

Limitations on the use of suction pumps include the following:

- External power source
- Vacuum will cause loss of dissolved gas, including volatile organics

- Restricted to areas with water levels within 10 to 25 feet of the ground surface
- Internal components of the pumps may be difficult to decontaminate

Gas-Lift Samples – This group of samplers uses gas pressure either in the annulus of the well or in a venture to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift pumps are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics. An inert gas such as nitrogen is generally used as a gas source.

Submersible Pumps – Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed air or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for two-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- Potentially low delivery rates
- Many models of these pumps are expensive
- Compressed gas or electric power is needed
- Sediment in water may cause clogging of the valves or eroding with impellers with some of these pumps
- Decontamination of internal components is difficult and time-consuming

4.4 Sampling

The sampling approach consisting of the following should be developed as part of the Field Sampling Plan prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Sampling equipment to be used.
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these should be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Schedule.

- List of team members.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

4.4.1 Sampling Methods

The collection of a groundwater sample includes the following steps:

- First open the well cap and use volatile organic detection equipment (HNu or OVA) on the escaping gases at the well head to determine the need for respiratory protection. This task is usually performed by the Field Team Leader, Health and Safety Officer, or other designee.
- When proper respiratory protection has been donned, measure the total depth and water level (with decontaminated equipment) and record these data in the field log book. Calculate the fluid volume in the well according to Section 5.2 of this SOP.
- Lower purging equipment or intake into the well to a distance just below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (e.g., DOT-approved 55-gallon drum).
- Measure the rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters. Record the method of discharge measurement.
- Observe peristaltic pump intake for degassing "bubbles" and all pump discharge lines. If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. The preferred method for collecting volatile organic samples and the accepted method by EPA Regions I through IV is with a bailer.
- Purge a minimum of three to five well volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recharge as necessary, but preferably to 70 percent of the static water level, and then sample.
- Record measurements of specific conductance, temperature, pH, and turbidity during purging to ensure that the groundwater level has stabilized. Generally, these measurements are made after the removal of three, four, and five well volumes.
- If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling (this requires use of other than a "bucket-type" bailer). Purged water should be collected in a designated container and disposed of in an acceptable manner.
- (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume

below the packer before sampling. Packers should always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

- In the event that groundwater recovery time is very slow (e.g., 24 hours), sample collection can be delayed until the following day. However, it is preferred that such a well be bailed early in the morning so that sufficient volume of water may be standing in the wall by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the log book.
- Add preservative if required. Label, tag, and number the sample bottle(s).
- Volatile organic septum vials (40 ml) should be completely filled to prevent volatilization and extreme caution should be exercised when filling a vial to avoid turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus". The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure. If the second attempt still produces air bubbles, note on Chain-of-Custody from and in field notebook and submit sample to the laboratory.
- Fill the remaining sample containers in order of decreasing volatilability (semi-volatiles next, then pesticides, PCBs, inorganics, etc.).
- Replace the well cap. Make sure the well is readily identifiable as the source of the samples.
- Pack the samples for shipping (see 9903-FSP-SOP-15). Attach custody seals to the shipping container. Make sure that Chain-of-Custody forms and Sample Analysis Request forms are properly filled out and enclosed or attached (see 9903-FSP-SOP-16).
- Decontaminate all equipment (see 9903-FSP-SOP-13).

4.4.2 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory. The QAPP describes the required sampling containers for various analytes at various concentrations. Container requirements shall follow those given in USEPA Standard Operating Procedures and Quality Assurance Manual (USEPA, 1991) and the QAPP.

4.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. The QAPP describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations.

Sample volume and preservation requirements shall follow those given in USEPA, 1991, and the QAPP.

4.4.4 Field Filtrater

In general, preparation and preservation of water samples for dissolved inorganics involve some form of filtration. All samples will be filtered in the field the same day as collection. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) utilizing the pressure provided by the upstream pumping device for its operation.

Filtration and preservation are to occur in the field on the same day as collected with the sample aliquot passing through a dedicated disposable 0.45 micron filter. Samples for organic analyses shall never be filtered.

4.4.5 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained “chemical” ice (e.g., “blue ice”) to reduce the risk of contamination. If water ice is used, it should be double-bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged, and thus, possibly become cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in 9903-FSP-SOP-15.

4.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in USEPA, 1991, and the QAPP.

5.0 Quality Assurance / Quality Control

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Log Book:

Sample identification (site name, location, project number, sample name/number and location; sample type and matrix, time and date, sampler’s identity).

- Sample source and source description
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method; volume of water purged prior to sampling; number of well volumes purged).
- Sample disposition (preservatives added; lab sent to; date and time).
- Additional remarks, as appropriate.

Proper chain-of-custody procedures play a crucial role in data gathering. 9903-FSP-SOP-16 describes the requirements for correctly completing a chain-of-custody form. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

6.0 Data and Records Management

6.1 The records generated in this procedure are part of the permanent record supporting the associated measurements and may include, as applicable, the field forms, sample tags, carrier waybills, and field records of sample history (collection, handling, storage, analysis, etc.).

6.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

7.0 Personnel Qualifications and Training

7.1 Qualifications and training

7.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

7.1.2 No specialized skills are needed to perform groundwater sampling.

7.2 Responsibilities

7.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

7.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

7.2.3 Project Manager – The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for the development of documentation of procedures which deviate from those presented herein.

7.2.4 Field Team Leader – The Field Team Leader is responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, and documenting these in accordance with the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

7.2.5 Sampling Personnel – It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and the Project Manager. The sampling personnel are responsible for the proper acquisition of groundwater samples.

8.0 References

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

American Society of Testing and Materials. 1987. Standard Guide for Sampling Groundwater Monitoring Wells. Method D4448-85A. Annual Book of Standards. ASTM. Philadelphia, Pennsylvania.

U.S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U.S. EPA, Environmental Services Division, Athens, Georgia.

9.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

Standard Operating Procedure

Chain-of-Custody Procedures

Procedure Number: 9903-FSP-SOP-16

Revision No.: 0

Revision Date: October 2010

______________________________ Date: ______________________________
SOP Author

______________________________ Date: ______________________________
Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________
Initials: ________ Date: ________

Standard Operating Procedure

Chain-of-Custody Procedures

Contents

Standard Operating Procedure

Chain-of-Custody Procedures

1.0 Scope and Applicability

Chain of custody (COC) is defined as the unbroken trail of accountability that ensures the physical security of samples, data, and records (EPA Glossary of Quality-Related Terms). This standard operating procedure (SOP) describes COC procedures applicable to environmental samples collected by AECOM during field sampling and analysis programs. Custody procedures within the laboratories analyzing the samples are not addressed.

Samples are physical evidence. The objective of COC procedures is to provide sufficient evidence of sample integrity to satisfy data defensibility requirements in legal or regulatory situations.

The National Enforcement Investigations Center (NEIC) of the U.S. Environmental Protection Agency (EPA) defines custody of evidence in the following manner:

- It is in your actual possession;
- it is in your view, after being in your physical possession;
- it was in your possession and then you locked or sealed it up to prevent tampering; or
- it is in a secure area.

This SOP is to be utilized to conduct the work identified in the title of this SOP. In the event the Project Manager or Project Team determines that the protocols and procedures listed in this SOP are not applicable to the project, there is the option to either adapt this SOP or to develop a site-specific SOP to more closely match the requirements of the project. Refer to SOP 1011, Preparation and Control of Standard Operating Procedures, for SOP modification and Project Operating Procedure (POP) development procedures.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Interferences

3.1 The following may impact the legal or regulatory defensibility of the data:

- The samples are not accompanied by a COC form,
- The information recorded on the COC form is incomplete, inaccurate, or differs from the information recorded on the sample containers,

- The documentation of person-to-person transfer of sample custody is incomplete, or contains unexplained gaps in time,
- COC seals or tape were not applied, were not applied correctly, or were lost or removed, for sample coolers/packages being transported by a party other than the sample custodian.

4.0 Equipment and Materials

The following materials are relevant to this procedure:

- COC Form (Figure 1)
- Sample labels
- COC tape or seal (Figure 2)
- Indelible pen or Sharpie TM
- Clear plastic sealing tape

Materials identified in related SOPs may also be needed specific information to be added as bulleted list. It is recommended that required vs. optional equipment be differentiated.]

5.0 Procedures

5.1 Pre-sample collection activities

5.1.1 Some measurement methods require preparation of sample collection media or special treatment of sample containers prior to sample collection. In these cases, COC procedures should be initiated with the media preparation or container treatment. This requires that sample identification numbers or media/container identification numbers be assigned. These numbers should be entered on the COC form, leaving room for the subsequent recording of the associated sample numbers. In this variation, the custodian responsible for media preparation or container treatment has the responsibilities outlined in Section 5.2, and the sampler or field sample custodian has the responsibilities stated in Section 5.3 when he or she receives the prepared media or treated containers. There are a number of acceptable approaches to this variation, and the detailed procedures should be defined in the project-specific QAPP.

5.2 Sample collection phase

5.2.1 As few people as possible should handle the samples. For certain programs, it is helpful if a single person is designated as the sample custodian (the person responsible for the care and custody of the samples until they are transferred to the laboratory for analysis).

5.2.2 While in the field, sampling personnel should be able to testify that tampering of the samples could not occur without their knowledge. Examples of actions taken may include sealing the sample containers with COC tape or locking the samples in a secure area.

5.2.3 If samples are to be shipped by commercial overnight carrier, the field sampler or sample custodian completes a COC form (Figure 1) for each cooler/package of samples and places the original of completed form inside the associated cooler/package before the package is sealed (a copy is retained and kept in the field record files). Each completed COC form should accurately list the sample identification numbers of the samples with which it is packaged, and should contain the identification number of the COC tape on the cooler/package. Representatives of commercial carriers are not required to sign the COC form. Refer to 9903-FSP-SOP-15 – Packaging and Shipment of Environmental Samples for specific packaging procedures.

5.2.4 If samples are hand carried to a laboratory, the person hand carrying the samples is the sample custodian. If the carrier is a different person than the one who filled out the COC form and packaged the samples, then that person transfers custody to the carrier by signing and dating each form in the "Relinquished By" section. The carrier then signs and dates each form in the adjacent "Received By" section. When the carrier transfers the samples to the laboratory, he or she signs and dates each form in the next "Relinquished By" section, and the laboratory sample custodian signs and dates each form in the adjacent "Received By" section.

5.2.5 If samples are transmitted to the laboratory by courier, the procedures described in either Section 5.2.3 or 5.2.4 are followed, depending on whether the courier is a commercial courier or laboratory representative, and whether the cooler has been secured by COC seals prior to pick up by a laboratory courier.

5.3 Sample labeling

5.3.1 Labeling of samples occurs at the time of sample collection.

5.3.2 Waterproof, adhesive labels are preferred. Labels should be applied to the container, not the lid whenever possible. Additional interior labels may be required for certain biological samples.

5.3.3 Sample tags may be required for certain projects requiring a strict level of legal or regulatory data defensibility. If tags are utilized, their use will be addressed in the project-specific work plan or QAPP.

5.3.4 Labels should be completed in waterproof, indelible ink. Covering the label with clear plastic tape is recommended to protect the legibility of the label and to prevent the label from detaching from the sample container.

5.3.5 The following information should be recorded on the sample label:

- Project identification (project name and number/client/site)
- Field sample identification code (exactly as it appears on the COC form)

- Sampler's initials
- Date and time of sample collection
- Analyses requested
- Preservation

5.4 Documentation of sample history

5.4.1 Sample history includes, but is not limited to, preparation of sample containers or collection media (for example, wipes), collection, handling (such as subsampling or compositing), storage, shipment, analytical preparation and analysis, reporting, and disposal.

5.4.2 Refer to 9903-FSP-SOP-01, Recording of Field Data, for specific guidance on documentation of field activities, field measurements, and sample collection.

5.5 Documentation of custody

5.5.1 It is recommended that a COC form (Figure 1 or equivalent) be initiated upon sample collection. If this is not feasible for a particular project, the COC form may be initiated at the time of sample packaging. If this is the case, the sample collection records will serve as the initial custody document and will document the collection of the sample (sample location and identification, date and time of collection, sampler, and parameters to be analyzed, including containers and preservatives).

5.5.2 The following information is recorded on the COC form:

- Project identification (AECOM project number, client, site name and location).
- Page number (for example, 1 of 2, 2 of 2).
- Field sample identification code. This code should be unique to the sampling event and to the program. This code should agree exactly with the field sample identification code recorded on the bottle label.
- Sampling point location (optional if recorded elsewhere in field records).
- Date and time of sample collection.
- Sample matrix (soil, water, air, etc.).
- Preservative.
- Analysis requested.
- Number of containers.
- Type of sample (grab or composite). Identifying if aqueous samples have been filtered in the field is recommended.
- Signature(s) of sampling personnel and signatures of all personnel handling, receiving, and relinquishing the samples.
- Date(s) and time(s) of each sample transfer.

- Sampler remarks. These comments may serve to alert the laboratory to highly contaminated samples or identify quality control (QC) sample requirements.
- Airbill number (if shipped by overnight commercial carrier).
- Laboratory name and address.
- COC tape numbers.

5.5.3 The COC is filled out completely and legibly in indelible ink. There should be no unexplained blank spaces. Blank lines should be lined out and initialed and dated.

5.5.4 Data will not obliterated. Corrections are made, if necessary, by drawing a single line through and initialing and dating the error. The correct information is then recorded with indelible ink.

5.5.5 Information on the COC should agree exactly with that recorded on the sample containers. Discrepancies may result in the samples being incorrectly logged into the laboratory or delays in initiating sample analysis.

5.6 Sample receipt and inspection

5.6.1 Upon sample receipt, the coolers or packages are inspected for general condition and the condition of the COC tape. The coolers or boxes are then opened and each sample is inspected for damage.

5.6.2 Sample containers are removed from packing material and sample label information is verified against the COC form.

5.6.3 The condition upon receipt, including any discrepancies or problems, is documented and the COC form is completed by signing and recording the date and time of receipt.

5.6.4 Receipt and inspection of samples by subcontractor analytical laboratories will adhere to written procedures established by the laboratory.

6.0 Quality Assurance / Quality Control

The records generated in this procedure are subject to review by the sampling team leader, project manager, or designee.

The records generated in this procedure will become a part of the evidence reviewed in the data validation process (see QAPP).

7.0 Data and Records Management

7.1 The records generated in this procedure are part of the permanent record supporting the associated measurements and may include, as applicable, the COC forms, sample tags, carrier waybills, and field and laboratory records of sample history (collection, handling, storage, analysis, etc.).

7.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) should be appropriately documented in the project records.

7.3 Records associated with the activities described in this SOP should be maintained according to the document management policy for the project.

7.4 Unanticipated changes to the procedures or materials described in this POP (deviations) will be appropriately documented in the project records.

7.5 Records associated with the activities described in this POP will be maintained according to the document management policy for the project.

8.0 Personnel Qualifications and Training

8.1 Qualifications and training

8.1.1 The individual executing these procedures should have read, and be familiar with, the requirements of this SOP.

8.1.2 No specialized skills are necessary in order to implement these procedures; however, an understanding of the concept of custody is useful.

8.2 Responsibilities

8.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

8.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

8.2.3 For certain sampling programs, the project manager, sampling team leader, or designee may assign an individual to serve as sample custodian. This individual is responsible for supervising the implementation of COC procedures in accordance with this SOP and any project-specific work plans or QAPP.

9.0 References

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

American Society for Testing and Materials (ASTM). 2004. Standard Guide for Sample Chain-of-Custody Procedures. D 4840-99 (Reapproved 2004).

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

10.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

AECOM

Standard Operating Procedure

Packaging and Shipment of Environmental Samples

Procedure Number: 54230-SI-SOP-09

Revision No.: 0

Revision Date: October 2010

________________________________ Date: ___________________________

SOP Author

________________________________ Date: ___________________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

Initials: ________ Date: ________

Standard Operating Procedure

Packaging and Shipment of Environmental Samples

Contents

Standard Operating Procedure

Packaging and Shipment of Environmental Samples

1.0 Scope and Applicability

1.1 This Standard Operating Procedure (SOP) describes the procedures associated with the packaging and shipment of environmental samples. Two general categories of samples exist: environmental samples consisting of water and soil submitted for routine environmental testing, and waste material samples which include non-hazardous solid wastes and/or hazardous wastes as defined by 40 CFR Part 261 submitted for environmental testing or bench/pilot-scale treatability testing. Packaging and shipping procedures will differ for the two sample categories.

1.2 This SOP is applicable to packaging and shipment of environmental samples submitted for routine environmental testing. Environmental samples are not considered a hazardous waste by definition; therefore, more stringent Department of Transportation (DOT) regulations regarding sample transportation do not apply. Environmental samples do, however, require fairly stringent packaging and shipping measures to ensure sample integrity as well as safety for those individuals handling and transporting the samples.

1.3 This SOP is designed to provide a high degree of certainty that environmental samples will arrive at their destination intact. This SOP assumes that samples will often require shipping overnight by a commercial carrier service, therefore, the procedures are more stringent than may be necessary if a laboratory courier is used or if samples are transported directly to their destination by a sampling team member. Should the latter occur, the procedures may be modified to reflect a lesser degree of packaging requirements.

1.4 Respective state or federal agency (regional offices) protocols may require or recommend specific types of equipment for use in sample packaging or a specific method of shipment that may vary from the indicated procedures. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.5 General Principles: Sample packaging and shipment generally involves the placement of individual sample containers into a cooler or other similar shipping container and placement of packing materials and coolant in such a manner as to isolate the samples, maintain the required temperature, and to limit the potential for damage to sample containers when the cooler is transported.

2.0 Health and Safety Considerations

2.1 Sampling personnel should be aware that packaging and shipment of samples involves potential physical hazards primarily associated with handling of occasional broken sample containers and lifting of heavy objects. Adequate health and safety measures must be taken to protect sampling personnel from these potential hazards. The project Health and Safety Plan (HASP) generally addresses physical and other potential hazards. This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed. In the absence of a HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Equipment and Materials

- Sample coolers
- Sample containers
- Shipping labels
- Chain-of-custody records, custody seals
- Bubble wrap
- "Blue Ice" refreezable ice packs, or ice cubes
- Transparent tape, or rubber bands
- Fiber tape
- Duct tape
- Zipper-lock plastic bags
- Trash bags
- Health and Safety supplies
- Equipment decontamination materials
- Field project notebook/pen

4.0 Procedures

4.1 General Information

4.1.1 Regulatory Information: The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. The EPA regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under the Resource Conservation and Recovery Act (RCRA) when any of the following conditions are applicable:

- Samples are being transported to a laboratory for analysis;
- Samples are being transported to the collector from the laboratory after analysis;

- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

4.1.2 Sample Information: The following information must accompany each shipment of samples on a chain-of-custody form (Attachment 1) where each sample has an individual entry:

- Sample collector's name, mailing address and telephone number,
- Analytical laboratory's name, mailing address and telephone number,
- A unique identification of each sample,
- Sample description (matrix),
- Number and type of sample containers,
- Container size,
- Preservative,
- Type and method of analysis requested, and
- Date and time that the samples were collected and prepared for shipping,
- Special handling instructions, including notation of suspected high concentration samples.

Complete chain-of-custody procedures are described in 9903-FSP-SOP-16

4.1.3 Laboratory Notifications: Prior to sample collection, the Project Manager, or designated alternative must notify the laboratory manager of the number, type and approximate collection and shipment dates for the samples. If the number, type or date of sample shipment changes due to program changes which may occur in the field, the Project Manager or alternate must notify the laboratory of the changes. Additional notification from the field is often necessary when shipments are scheduled for weekend delivery.

4.2 General Site Preparation

4.2.1 Small Projects: Small projects of one or two days duration may require packaging and shipment of samples using the field vehicle as the sample preparation area. If sample coolers will be sent via third party commercial carrier service, adequate sample packaging materials should be sent to the project location in advance of sampling or purchased from stores located near the site.

4.2.2 Large Projects: Multi-day or week sampling programs usually require rental of an office trailer or use of existing office/storage facilities for storage of equipment as well as for sample preparation. If possible, a designated area should be selected for storage of unused sample containers/coolers and another area for sample handling, packaging, and shipment. Handling of environmental samples should preferably be conducted in a clean area and away from unused sample containers to minimize the potential for cross contamination. Large quantities of packaging materials may require advance special ordering. Shipping forms/labels may be preprinted to facilitate shipping.

4.2.3 Cooler Inspection and Preparation: Laboratories will often re-use coolers. Every cooler received at a project location should be inspected for condition and cleanliness. Any coolers that have cracked interior or exterior linings/panels or hinges should be discarded as their insulating properties are now compromised. Any coolers missing one or both handles should also be discarded if replacement handles (i.e., knotted rope handles) can not be fashioned in the field. Replacement coolers may be purchased in the field if necessary.

The interior and exterior of each cooler should be inspected for cleanliness before using it. Excess strapping tape and old shipping labels should be removed. If the cooler interior exhibits visible contamination or odors it should be decontaminated in accordance with 54230-SI-SOP-07 (Decontamination of Equipment) prior to use. Drain plugs should be sealed on the inside with duct tape.

4.2.4 Other Considerations:
VOC Samples - Sample containers used for VOC analysis may be grouped into a single cooler, with separate chain-of-custody record, to limit the number of trip blanks required for transportation and analysis. Individual VOC samples may also be placed into Zipper-lock bags to further protect the samples.

Contaminated Samples - Sample containers with presumed high contaminant concentrations should be isolated within their own cooler with each sample container placed into a Zipper-lock bag.

4.3 Sample Packaging Method
Sample packaging should be conducted in the following manner:

4.3.1 Place plastic bubble wrap matting over the base of each cooler or shipping container as needed. A 2- to 3-inch thickness layer of vermiculite may be used as a substitute base material.

4.3.2 4.3.2 Insert a clean trash bag into the cooler to serve as a liner.

4.3.3 Check that each sample container is sealed, labelled legibly, and is externally clean. Re-label and/or wipe bottles clean if necessary. Clear tape should be placed over the labels to protect them. Wrap each sample bottle individually with bubble wrap secured with tape or rubber bands. Place bottles into the cooler in an upright single layer with approximately one inch of space between each bottle. Do not stack bottles or place them in the cooler lying on their side. If plastic and glass sample containers are used, alternate the placement of each type of container within the cooler so that glass bottles are not placed side by side. Insert cooler temperature blanks if required.

4.3.4 Place additional vermiculite, bubble wrap, and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler to a level which meets the approximate top of the sample containers. Packing material may require tamping by hand to reduce the potential for settling.

4.3.5 Place cubed ice or cold packs in heavy duty Zip-lock type plastic bags, close the bags, and distribute the packages in a layer over the top of the samples. Cubed ice should be double-bagged to prevent leakage. Loose ice should never be used. Cold packs should be used only if the samples are chilled before being placed in the cooler.

4.3.6 Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

4.3.7 Obtain two pieces of chain of custody tape, as example shown in Attachment 2, and enter the custody tape numbers in the appropriate place on the chain-of-custody form. Sign and date the chain-of-custody tape.

4.3.8 Complete the chain-of-custody form. If shipping the samples involves use of a third party commercial carrier service, sign the chain-of-custody record thereby relinquishing custody of the samples. Shippers should not be asked to sign chain of custody records. If a laboratory courier is used, or if samples are transported to the laboratory, the receiving party should accept custody and sign the chain-of-custody records. Remove the last copy from the form and retain it with other field notes. Place the original (with remaining copies) in a Zipper-lock type plastic bag and tape the bag to the inside lid of the cooler or shipping container.

4.3.9 Close the top or lid of the cooler or shipping container.

4.3.10 Place the chain of custody tape at two different locations (i.e., one tape on each side) on the cooler or container lid and overlap with transparent packaging tape.

4.3.11 Packaging tape should be placed entirely around the sample shipment containers. A minimum of two full wraps of packaging tape will be placed at least two places on the cooler.

4.3.12 Repeat the above steps for each cooler or shipping container.

4.4 Sample Shipping Method
Packaged sample coolers should be shipped using one of the following options:

4.4.1 Hand Delivery: When a project member is transporting samples by automobile to the laboratory, the cooler should only be sealed with tape. In these cases, chain¬of-custody will be maintained by the person transporting the sample and chain-of-custody tape need not be used. Chain-of-custody records should be relinquished upon delivery and a copy of the record retained in the project file.

4.4.2 Laboratory Courier: Laboratory couriers are usually employees of the analytical laboratory receiving the samples. As such, they will accept custody of the samples and must be asked to sign the chain-of-custody records. Chain-of-custody records do not need to be sealed in the cooler although it is recommended that the coolers be sealed with tape. All other packaging requirements generally apply unless otherwise specified in the QAPP.

If the laboratory courier is not authorized to accept custody of the samples, or if the requirements of the project plan preclude transfer to the laboratory courier, samples will be handled as described below in Section 5.4.3.

4.4.3 Third Party Courier: If overnight shipment is required, a third party package delivery service should be used. Transport the cooler to the package delivery service office or arrange for package pick-up at the site. Fill out the appropriate shipping form or airbill and affix it to the cooler. Some courier services may use multi-package shipping forms where only one form needs to be filled out for all packages going to the same destination. If not, a separate shipping form should be used for each cooler. Keep the receipt for package tracking purposes should a package become lost. Please note that each cooler also requires a shipping label which indicates point of origin and destination. This will aid in recovery of a lost cooler if a shipping form gets misplaced. Never leave coolers unattended while waiting for package pick-up. Airbills or waybills will be maintained as part of the custody documentation.

4.5 Sample Receipt
Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each chain-of-custody form. The laboratory will verify that the chain-of-custody tape has not been broken previously and that the tape number corresponds with the number on the chain-of-custody record. The laboratory will note the condition of the samples upon receipt and will identify any discrepancies between the contents of the cooler and chain-of-custody. The analytical laboratory will then forward the back copy of the chain-of-custody record to the project manager to indicate that sample transmittal is complete.

5.0 Quality Assurance / Quality Control

5.1 Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific work plan or Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will specify sample packaging and shipment requirements if variations to the indicated procedures are necessary on a particular project.

5.2 The potential for samples to break during transport increases greatly if individual containers are not snugly packed into the cooler. Completed coolers may be lightly shake-tested to check for any loose bottles. The cooler should be repacked if loose bottles are detected.

5.3 Environmental samples are generally shipped so that the samples are maintained at a temperature of approximately 4°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks usually are supplied by the laboratory and consist of a 40-ml vial or plastic bottle filled with tap water. Temperature blanks should be placed near the center of the cooler.

6.0 Data and Records Management

6.1 Documentation supporting sample packaging and shipment generally consists of chain-of-custody records and shipping records. In addition, a description of sample packaging procedures will be written in the field project notebook. All documentation will be retained in the project files following project completion.

6.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

7.0 Personnel Qualifications and Training

7.1 Qualifications and training

7.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

7.1.2 Sample packaging and shipment is a relatively simple procedure requiring minimal training and a minimal amount of equipment. It is, however, recommended that initial attempts be supervised by more experienced personnel. Sampling technicians should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

7.2 Responsibilities

7.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

7.2.2 It is the responsibility of the sampling technician to be familiar with the procedures outlined within this SOP and with specific sampling, quality assurance, and health and safety requirements outlined within the project-specific plans. The sampling technician is responsible for proper packaging and shipment of environmental samples and for proper documentation of sampling activities for the duration of the sampling program.

7.2.3 Large sampling programs may require additional support personnel such as a sampling coordinator. The sampling coordinator is responsible for providing management support such as maintaining an orderly sampling process, providing instructions to sampling technicians regarding sampling locations, and fulfilling sample documentation requirements, thereby allowing sampling technicians to collect samples in an efficient manner.

7.2.4 The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the activities in accordance with the project plan and this SOP. The project manager is also responsible for ensuring that proper arrangements have been made with the designated analytical laboratory. These arrangements include, but are not necessarily limited to, subcontractor agreements, analytical scheduling, and bottle/cooler orders. The project manager may delegate some of these responsibilities to other project staff.

8.0 References

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

9.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

Standard Operating Procedure

Low Flow Groundwater Sampling

Procedure Number: 9903-FSP-SOP-12

Revision No.: 0

Revision Date: October 2010

____________________________ Date: ____________________________

SOP Author

____________________________ Date: ____________________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

Initials: ________ Date: ________

Standard Operating Procedure

Low Flow Groundwater Sampling

Contents

Standard Operating Procedure
Low Flow Groundwater Sampling

1.0 Scope and Applicability

1.1 This SOP describes methods used to obtain the collection of valid and representative groundwater samples from monitoring wells utilizing a low flow sampling technique. This technique is designed to reduce the influx of particulate matter into the well and groundwater sample to ensure a more representative analysis of groundwater quality, and to reduce aeration that can affect geochemical parameters.

1.2 This guideline provides information on proper sampling equipment and techniques for low-flow groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques that will meet low-flow criteria. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustment in methods.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Equipment and Materials

The following list of equipment will be used to determine the depth to water, purged volume, and analytical parameters.

3.1 Sampling/Purging Equipment

- Low flow submersible bladder pump or peristaltic sampling pump
- Teflon and polyethylene tubing
- Water level measurement equipment

3.2 Field Analytical Parameter Measurement

- In-line water quality meter (e.g., flow-through cell)
- Water quality meter with individual temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, salinity, and oxidation reduction potential (ORP) probes
- Turbidity meter

3.3 Supporting Documents

- Project specific Work Plan
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP Field data sheets and log book

3.4 Decontamination Equipment

- Distilled water
- Isopropanol (laboratory grade)
- Spray bottles for decontamination solutions Chemical free paper towels

3.5 Sample Collection

- Preservation solutions (if necessary)
- Sample containers
- Coolers

3.6 Peristaltic Pump Sample Collection

- Generator and extension cord
- Battery packs

3.7 Bladder Pump Sample Collection

- Dedicated bladders Pump controller box
- Nitrogen (air supply) Detergent/Alconox
- Nitric or hydrochloric acid (laboratory grade)
- Cleaning brushes

3.8 Miscellaneous

- Disposable gloves
- Tubing cutters
- Plastic sheeting
- PPE
- Buckets and intermediate containers

4.0 Procedures

The following sections describe the methods and procedures required to collect representative low-flow groundwater samples.

4.1 Water Level Management

After unlocking and/or opening a monitoring well, the first task will be to obtain a water level measurement. A static-water level will be measured in the well prior to the purging and collection of any samples. The water level is needed for estimating the purge volume and may also be used for mapping the potentiometric surface of the groundwater. Water-level measurements will be made using an electronic or mechanical device following the methods described in 9903-FSP-SOP-09.

Measurement of point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form (attached). Whatever measuring point is used, the location should be described on the groundwater sampling form.

To obtain a water level measurement lower a decontaminated mechanical or an electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement. The water-level measurement should be entered on the groundwater sampling form. The water-level measurement device shall be decontaminated immediately after use following the procedures outlined in 9903-FSP-SOP-13 (Decontamination).

4.2 Purging and Sampling Collection

4.2.1 Pumping: At least 14 days should be allowed for well equilibration after well installation and/or development prior to sampling. Purging must be performed for all groundwater monitoring wells prior to sample collection. The volume of water present in each well must be computed using two measurable lengths, length of water the water column and monitoring well inside diameter. A low flow, electric driven pump (e.g., bladder pump or peristaltic pump) will be used to purge and sample well water.

The inlet of the bladder pump or peristaltic pump tubing will be lowered into the well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer, or 1-2 feet below the water level in the well, whichever is greater. A depth-to-water measurement device will be lowered into the well to monitor drawdown. The pump will be turned on at a flow rate of about 0.1 liters per minute (L/min). The flow rate will be adjusted up or down to maximize flow, yet ensure minimum drawdown. In no instance should a drawdown of more than 0.5 foot be allowed. The water level in the well should be carefully monitored to ensure that draw down does not increase during purging.

4.2.2 Field Parameters: Groundwater will be pumped from the well into a sealed, flow-through chamber containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a Water Quality Meter. Field measurements of turbidity will also be obtained using a turbidity meter for comparison purposes. It is essential to properly calibrate the Water Quality Meter for the specific parameters being monitored, according to the procedures identified in the instrument manual. Calibration procedures and results must be documented in the site field notebook.

Field parameters values will be recorded on the Groundwater Sample Collection Record (Figure 1) or in the site field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the container is full, the water will be properly disposed following Site protocols.

Groundwater samples will be collected for laboratory analysis when the groundwater has stabilized; the change between successive readings of temperature, pH and conductivity are less than 10%, and turbidity is reduced to 10 NTUs or less. This may occur prior to removal of three well volumes. Stabilization of groundwater measurements are considered indicative of sampling fresh formation water and is a more reliable indicator of purging than removal of a standard volume of water.

4.2.3 Decontamination: Decontamination of non-dedicated equipment will follow the procedures outlined in 9903-FSP-SOP-13 (Decontamination), or following the procedures listed below for full field decontamination, conducted in the order presented:

- Remove gross contamination from the equipment by brushing
- Wash with non-phosphate soap/detergent solution
- Rinse with laboratory-grade nitric acid (for potential inorganic contamination) Rinse with tap water
- Rinse with laboratory grade isopropanol
- Rinse with tap water Rinse with distilled water Allow to air dry
- Repeat as necessary

Polyethylene tubing will be dedicated to each well and will, therefore, not require decontamination.

4.3 Sample Preparation

Proper packaging and shipment of samples will minimize the potential for sample breakage, leakage, or cross contamination and will provide a clear record of sample custody from collection to analysis. Information on sample custody and shipping is also detailed in 9903-FSP-SOP-15 (Packaging and Shipment of Samples). Samples will be packaged on ice and shipped in a container able to maintain a temperature at or below 4^{o}C.

5.0 Quality Assurance / Quality Control

5.1 Proper packaging and shipment of samples will minimize the potential for sample breakage, leakage, or cross contamination and will provide a clear record of sample custody from collection to analysis. Information on sample custody and shipping is also detailed in 9903-FSP-SOP-15 (Packaging and Shipment of Samples). Samples will be packaged on ice and shipped in a container able to maintain a temperature at or below $4^{o}C$.

6.0 Data and Records Management

6.1 The records generated in this procedure are part of the permanent record supporting the associated measurements and may include, as applicable, the field forms, carrier waybills, and field records of sample history (collection, handling, storage, analysis, etc.).

6.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

7.0 Personnel Qualifications and Training

7.1 Qualifications and training

7.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

7.1.2 No specialized skills are needed to perform low flow groundwater sampling.

7.2 Responsibilities

7.2.1 The field sampling coordinator will have responsibility to oversee and ensure that all groundwater sampling is performed in accordance with the project specific sampling program and this SOP. It shall be the responsibility of the field sampling coordinator to observe all activities pertaining to sampling to ensure that all the standard procedures are followed properly, and to record all pertinent data on a field log or field book. The collection, handling, and storage of all samples will be the responsibility of the field sampling coordinator. In addition, the field sampling coordinator must ensure that all field workers are fully apprised of this SOP.

7.2.2 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

7.2.3 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

8.0 References

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

[Additional references added as necessary]

9.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

Well ID:

AECOM

Low Flow Ground Water Sample Collection Record

Client: ______ Date: ______ Time: Start ______ am/pm
Project No: ______ Finish ______ am/pm
Site Location: ______
Weather Conds: ______ Collector(s): ______

1. WATER LEVEL DATA: (measured from Top of Casing)

a. Total Well Length ______ c. Length of Water Column ______ (a-b)

Casing Diameter/Material ______

b. Water Table Depth ______ d. Calculated System Volume (see back) ______

2. WELL PURGE DATA

a. Purge Method: ______

b. Acceptance Criteria defined (see workplan)

- Temperature	3%	-D.O.	10%
- pH	± 1.0 unit	- ORP	± 10mV
- Sp. Cond.	3%	- Drawdown	< 0.3'

c. Field Testing Equipment used: Make Model Serial Number

Time (24hr)	Volume Removed (Gallons)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Color/Odor

(continued on back)

d. Acceptance criteria pass/fail	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

If no or N/A - Explain below.

______

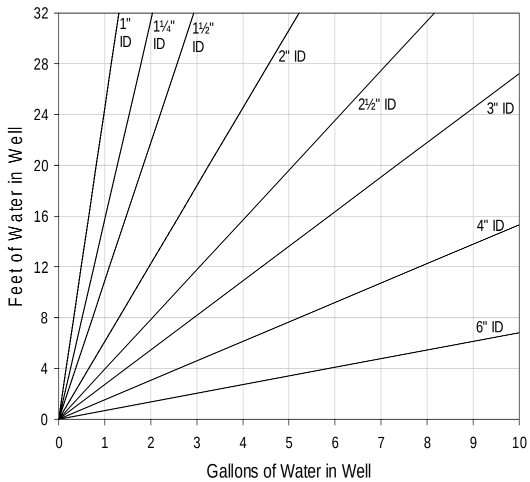
3. SAMPLE COLLECTION: Method: ______

Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time

Comments ______

Signature ______ Date ______

Purge Volume Calculation



Volume / Linear Ft. of Pipe		
ID (in)	Gallon	Liter
0.25	0.0025	0.0097
0.375	0.0057	0.0217
0.5	0.0102	0.0386
0.75	0.0229	0.0869
1	0.0408	0.1544
1.25	0.0637	0.2413
1.5	0.0918	0.3475
2	0.1632	0.6178
2.5	0.2550	0.9653
3	0.3672	1.3900
4	0.6528	2.4711
6	1.4688	5.5600

(continued from front)

Time (24 hr)	Volume Removed (Gallons)	Temp (°C)	pH	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (ft)	Color/Odor

AECOM

Standard Operating Procedure

Decontamination of Field Equipment

Procedure Number: 9903-FSP-SOP-13

Revision No.: 0

Revision Date: October 2010

____________________ Date: ____________________

SOP Author

____________________ Date: ____________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

Initials: ________ Date: ________

Contents

Standard Operating Procedure
Decontamination of Field Equipment

1.0 Scope and Applicability

1.1 Scope and Applicability

1.1.1 This SOP describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. The list of field equipment may include a variety of items used in the collection of soil and/or water samples, such as split-spoon samplers, trowels, scoops, spoons, bailers and pumps. Heavy equipment such as drill rigs and backhoes also require decontamination, usually in a specially constructed temporary decontamination area.

1.1.2 Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination. Decontamination protects field personnel from potential exposure to hazardous materials. Decontamination also protects the community by preventing transportation of contaminants from a site.

1.1.3 This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Occasionally, dedicated field equipment such as well construction materials (well screen and riser pipe) or disposable field equipment (bailers or other general sampling implements) may also require decontamination prior to use. The project-specific work plan should indicate the specific decontamination requirements for a particular project.

1.1.4 Respective state or federal agency (regional offices) regulations may require specific types of equipment or procedures for use in decontamination of field equipment. The project manager should review the applicable regulatory requirements, if any, prior to the start of the field investigation program.

1.2 General Principles

1.2.1 Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, steam and/or high pressure water, or solvents. The decontamination method and agents are generally determined on a project-specific basis and must be stated in the Sampling and Analysis Plan (SAP) or the Quality Assurance Project Plan (QAPP).

1.2.2 Generally, decontamination of equipment is accomplished at each sampling site between collection points. Waste decontamination materials such as spent liquids and solids will be collected and managed as investigation-derived waste for later disposal. All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the quantity of materials used or produced throughout the investigation program.

1.3 Quality Assurance Planning Considerations

1.3.1 General Considerations: Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific SAP of QAPP. The QAPP guidelines typically require collection of equipment blank samples in order to determine the effectiveness of the decontamination procedure.

The decontamination method, solvent, frequency, location on site and the method of containment and disposal of decontamination wash solids and solutions are dependent on site logistics, site-specific chemistry, and nature of the contaminated media to be studied and the objectives of the study. Each topic must be considered and addressed during development of a decontamination strategy and should be outlined in the SAP or the QAPP.

1.3.2 Solvent Section: There are several factors which need to be considered when deciding upon a decontamination solvent. The solvent should not be an analyte of interest. The sampling equipment must be resistant to the solvent. The solvent must be evaporative or water soluble or preferably both. The applicable regulatory agency may have specific requirements regarding decontamination solvents. The SAP or the QAPP should specify the type of solvent to be used for a particular project.

The analytical objectives of the study must also be considered when deciding upon a decontamination solvent. Pesticide-grade methanol is the solvent of choice for general organic analyses. It is relatively safe and effective. Hexane, acetone, and isopropanol are sometimes used as well. A 10% nitric acid in deionized water solution is the solvent of choice for general metals analyses. Nitric acid can be used only on Teflon, plastics and glass. If used on metal equipment, nitric acid will eventually corrode the metal and lead to the introduction of metals to the collected samples. Dilute hydrochloric acid is usually preferred over nitric acid when cleaning metal sampling equipment.

Equipment decontamination should be performed a safe distance away from the sampling area so as not to interfere with sampling activities but close enough to the sampling area to maintain an efficient working environment. If heavy equipment such as drill rigs or backhoes are to be decontaminated, then a central decontamination station should be constructed with access to a power source and water supply.

2.0 Health and Safety Considerations

2.1 Decontamination procedures may involve chemical exposure hazards associated with the type of contaminants encountered or solvents employed and may involve physical hazards associated with decontamination equipment. When decontamination is performed on equipment which has been in contact with hazardous materials or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination, and must be adhered to as field activities are performed.

3.0 Equipment and Materials

3.1 Decontamination agents (per work plan requirements) may include:

- LIQUI-NOX, ALCONOX, or other phosphate-free biodegradable detergent,
- Tap water,
- Distilled/deionized water,
- Nitric acid and/or hydrochloric acid,
- Methanol and/or hexane, acetone, isopropanol.
- Health and Safety equipment
- Chemical-free paper towels
- Waste storage containers: drums, 5-gallon pails w/covers, plastic bags
- Cleaning containers: plastic buckets or tubs, galvanized steel pans, pump cleaning cylinder
- Cleaning brushes
- Pressure sprayers
- Squeeze bottles
- Plastic sheeting
- Aluminum foil
- Field project notebook/pen

4.0 Procedures

4.1 General Preparation

4.1.1 It should be assumed that all sampling equipment, even new items, are contaminated until the proper decontamination procedures have been performed on them or unless a certificate of analysis is available which demonstrates the items cleanliness.

4.1.2 Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears contaminated and/or has been stored for long periods of time. Unless customized procedures are stated in the QAPP for decontamination of equipment, the standard procedures specified in this SOP shall be followed.

4.1.3 Establish the decontamination station within an area that is convenient to the sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station, or a portable decontamination station should be established.

4.1.4 An investigation-derived waste (IDW) containment station should be established at this time also. The project-specific work plan should specify the requirements for IDW containment. In general, decontamination solutions are discarded as IDW between sampling locations. Solid waste is disposed of as it is generated.

4.2 Decontamination for Organic Analyses

4.2.1 This procedure applies to soil sampling and groundwater sampling equipment used in the collection of environmental samples submitted for organic constituents analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items. Submersible pump decontamination procedures are outlined in Section 5.4.

4.2.2 Decontamination is to be performed before sampling events and between sampling points.

4.2.3 After a sample has been collected, remove all gross contamination from the equipment or material by brushing and then rinsing with available tap water. This initial step may be completed using a 5-gallon pail filled with tap water. Steam or a high-pressure water rinse may also be conducted to remove solids and/or other contamination.

4.2.4 Wash the equipment with a phosphate-free detergent and tap water solution. This solution should be kept in a 5-gallon pail with its own brush.

4.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle or pressure sprayer.

4.2.6 Rinse with methanol or other appropriate solvent using a squeeze bottle or pressure sprayer. Rinsate should be collected in a waste bucket.

4.2.7 Rerinse with deionized water to remove any residual solvent. Rinsate should be collected in the solvent waste bucket.

4.2.8 Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in tin foil and/or seal it in a plastic bag if it will not be reused for a while.

4.2.9 Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

4.3 Decontamination for Inorganic (Metals) Analyses

4.3.1 This procedure applies to soil sampling equipment used primarily in the collection of environmental samples submitted for inorganic constituents analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items.

4.3.2 For plastic and glass sampling equipment, follow the steps outlined in 5.2 above, however, use a 10% nitric acid solution (acid in water) in place of the solvent rinse in Section 5.2.6.

4.3.3 For metal sampling equipment, follow the steps outlined in 5.2 above, however, use a 10% hydrochloric acid solution (acid in water) in place of the solvent rinse in Section 5.2.6.

4.4 *Decontamination of Submersible Pumps*

4.4.1 This procedure will be used to decontaminate submersible pumps before and between ground-water sample collection points. This procedure applies to both electric submersible and bladder pumps. This procedure also applies to discharge tubing if it will be reused between sampling points.

4.4.2 Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump and tubing may be removed from the well and placed into a clean trash bag for transport to the decontamination area. Pump decontamination is easier with the use of 3-foot tall pump cleaning cylinders (i.e., Nalgene cylinder) for the various cleaning solutions, although the standard bucket rinse equipment may be used.

4.4.3 Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, place it on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

4.4.4 As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump, discharge line, and power cord as necessary. Collect the rinsate and handle as IDW.

4.4.5 Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (detergent in tap water). Holding the tubing/power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

4.4.6 Place the pump into another cylinder/bucket containing a 10% solution of solvent (methanol, or other designated solvent) in distilled/deionized water. Pump until the detergent solution is removed. Collect the rinsate and handle as IDW.

4.4.7 Place the pump into another cylinder/bucket containing distilled/deionized water. Pump a minimum of 3 to 5 pump system volumes (pump and tubing) of water through the system. Collect the rinsate and handle as IDW.

4.4.8 Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

4.4.9 Rinse the exterior of the pump, discharge line, and power cord thoroughly using distilled/deionized water, shake out all excess water, then place the pump system into a clean trash bag for storage. If the pump system will not be used again right away, the pump itself should also be wrapped with aluminum foil before placing it into the bag.

4.5 Decontamination of Large Equipment

4.5.1 On large projects usually a temporary decontamination facility (decontamination pad) is required which may include a membrane-lined and bermed area large enough to drive heavy equipment (drill rig, backhoe) onto with enough space to spread other equipment and to contain overspray. Usually a small sump with pump is necessary to collect and contain rinsate. A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

4.5.2 Upon arrival and prior to leaving a sampling site, all heavy equipment such as drill rigs, trucks, and backhoes should be thoroughly cleaned and then the parts of the equipment which come in contact or in close proximity to sampling activity should be decontaminated. This can be accomplished in two ways, steam cleaning or high pressure water wash and manual scrubbing. Following this initial cleaning, only those parts of the equipment which come in close proximity to the sampling activities (i.e., auger stems, rods, backhoe bucket) must be decontaminated in between sampling events.

4.5.3 Occasionally, well construction materials such as well screen and riser pipe may require decontamination before the well materials are used. These materials may be washed in the decontamination pad, preferably on a raised surface above the pad (i.e., on sawhorses), with clean plastic draped over the work surfaces. Well materials usually do not require a multistep cleaning process as they generally arrive clean from the manufacturer. Usually, a thorough steam-cleaning of the interior/exterior of the well materials will be sufficient. The QAPP should provide specific guidance regarding decontamination of well materials.

5.0 Quality Assurance / Quality Control

5.1 *Field Blank Sample Collection*

5.1.1 General guidelines for quality control check of field equipment decontamination usually require the collection of one field blank from the decontaminated equipment per day. The QAPP should specify the type and frequency of collection of each type of quality assurance sample.

5.1.2 Field blanks are generally made by pouring laboratory-supplied deionized water into, over, or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Field blanks should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated sample. Field blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

6.0 Data and Records Management

6.1 Specific information regarding decontamination procedures should be documented in the project-specific field notebook. Documentation within the notebook should note the decontamination steps implemented in order to show compliance with the project work plan. Activities associated with decontamination events should be logged when they occur, including:

- Identification of field blanks and decontamination rinsates
- Method of blank and rinsate collection
- Date, time and location of blank and rinsate collection
- Disposition of IDW

6.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

7.0 Personnel Qualifications and Training

7.1 Qualifications and training

7.1.1 All sampling technicians performing decontamination must be properly trained in the decontamination procedures employed, the project data quality objectives, health and safety procedures and the project CIA procedures. Specific training or orientation will be provided for each project to ensure that personnel understand the special circumstances and requirements of that project. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

7.2 Responsibilities

7.2.1 Sampling Technician: It is the responsibility of the sampling technician to be familiar with the decontamination procedures outlined within this SOP and with specific quality assurance, and health and safety requirements outlined within project-specific work plans (HASP, QAPP). The sampling technician is responsible for decontamination of field equipment and for proper documentation of decontamination activities. The sampling technician is also responsible for ensuring that decontamination procedures are followed by subcontractors when heavy equipment requires decontamination.

7.2.2 Field Project Manager: The field project manager is responsible for ensuring that the required decontamination procedures are followed at all times. The project manager is also responsible for ensuring that subcontractors construct and operate their decontamination facilities according to project specifications. The project manager is responsible for collection and control of IDW in accordance with project specifications.

8.0 References

Not applicable.

9.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

Standard Operating Procedure

Handling of Site Investigation Derived Wastes Procedure

Procedure Number: 9903-FSP-SOP-14

Revision No.: 0

Revision Date: October 2010

______________________ Date: ______________________

SOP Author

______________________ Date: ______________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

Initials: ________ Date: ________

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Standard Operating Procedure

Handling of Site Investigation Derived Wastes Procedure

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Standard Operating Procedure

Handling of Site Investigation Derived Wastes Procedure

1.0 Scope and Applicability

The purpose of this SOP is to provide guidance for disposal of investigation derived wastes (IDW) generated under a field investigation program.

This procedure describes the steps necessary to dispose of site investigation derived wastes that are generated during field investigations. These wastes may be either hazardous or nonhazardous in nature. The nature of the waste (hazardous or nonhazardous) will determine how the wastes will be handled during the field investigation. The sources of waste material depend on the site activities planned for a project. The following types of activities (or sources) that are typical of site investigations may result in the generation of waste material which must be properly handled.

- Soil borings and monitoring well construction (drill cuttings)
- Mud rotary drilling (potentially contaminated mud)
- Monitoring well development (development water)
- Groundwater sampling (purge water)
- Heavy equipment decontamination (decontamination fluids)
- Sampling equipment decontamination (decontamination fluids)
- Personal protective equipment (PPE) (health and safety disposables)

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this POP, including both potential physical and chemical hazards, will be addressed in the site specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Procedures

3.1 Investigation Derived Waste (IDW). A waste (hazardous or nonhazardous) generated during a field investigative task that has been properly labeled, stored, and containerized while awaiting final disposition. These wastes may include drilling muds, soil cuttings, and purge water from test pit and well installation, purge water, soil and other materials from collection of samples; residues (e.g., ash, spent-carbon, well development purge water) from testing of treatment technologies and pump and treat systems; contaminated PPE; and solutions used to decontaminate non-disposable PPE and equipment (USEPA, April, 1992, Guide to Management of Investigation-Derived Wastes).

3.2 Preliminary Activities

Prior to the initiation of site activities the expected sources, media, and method(s) of containerizing and staging of these materials will be identified.

3.3 Designation of Potentially Hazardous and Nonhazardous IDW

Wastes generated during the field investigation can be categorized as either potentially hazardous or nonhazardous in nature.. The designation of such wastes will determine how the wastes will be handled. The criteria for determining the nature of the waste, and the subsequent handling, is described below foe each type of investigative waste.

3.3.1 Drill Cuttings/Mud

Drill cuttings and mud generated during the augering of test (soil) borings and monitoring well installation boreholes, will be containerized in 55-gallon drums or in lined roll-off boxes. As the boreholes is augered, and soil samples collected, the site geologist will monitor the cuttings/samples with an HNu photoionization (PID) unit for organic vapors. In addition, the site geologist will describe the soils in a Field Logbook. Upon completion, the soil borings will be backfilled with a cement-bentonite grout.

3.3.2 Monitoring Well Development and Purge Water

All site development and purge water shall be containerized in 55-gallon drums, tankers, or large (250-gallon) containers. 55-Gallon drums will initially be strategically located at the site (i.e., next to each well).

3.3.3 Decontamination Fluids

Equipment and personal decontamination fluids shall be containerized in 55-gallon drums or tanks, if appropriate. The fluids shall be collected from each of the "decon"/wash pads on a daily basis. Decontamination fluids containing solvents and/or acids may be containerized separately.

3.3.4 Personal Protective Equipment

All personal protective equipment (e.g., tyvek, gloves, and other health and safety disposables) shall be double bagged and placed in a 55-gallon drum.

3.4 Containerization

Waste materials should be segregated to minimize disposal quantities of hazardous materials. For instance, soils from a particular boring may be placed in a single set of containers for that boring.

Polyethylene or other suitably compatible liners will be used in roll-off boxes for solids. The containers are to remain closed except when filling, emptying or sampling. The container lid shall be securely attached at the end of each work day or when the container is completely empty.

3.5 Labeling

- Date
- Site number
- Project number
- Boring or well number
- Matrix (liquid, solid)
- Contents (dev. Water, decon fluids, etc.)

If laboratory analysis reveals that containerized materials are hazardous or contain PCBs, additional labeling of containers may be required. These additional labeling procedures will be based upon the identification of material present; EPA regulations applicable to labeling hazardous and PCB wastes are contained in 40 CFR Parts 261, 262 and 761.

3.6 Container Storage

Containers of site investigation wastes shall be stored in a designated and secure area that is managed by the client until disposition is determined.

If the laboratory analysis reveals that the containers hold hazardous or PCB waste, additional storage and/or security measures may be implemented.

Storage requirements may include the drums being staged for easy access or on wood pallets or other structures to prevent contact with the ground. Weekly inspections of the temporary storage area by facility personnel may also be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. These weekly inspections and precipitation removal events, shall be recorded in the site Logbook.

3.7 Container Disposition

The disposition of containers of site investigation generated wastes shall be determined by the Client and regulatory personnel, as necessary. Disposition of the containerized waste shall be based on quantity, types of material, and analytical results. If necessary, samples of the containerized waste may be collected for waste characterization purposes. Disposition will not be addressed until after receipt of applicable analytical results; these results are usually not available until long after completion of the field investigation at the facility.

3.8 Disposal of Contaminated Materials

Actual disposal methods for contaminated materials disturbed during a site investigation are the same as for other PCB or hazardous substances; incineration, landfilling, treatment, and so forth. The responsibility for the disposal must be determined and agreed upon by all involved parties during negotiations addressing this contingency.

The usual course will be a contractor specialist retained to conduct the disposal. However, regardless of the mechanism used, all applicable Federal, state and local regulations shall be observed. EPA regulations applicable to generating, storing and transporting PCB or hazardous wastes are contained in 40 CFR parts 262, 263 and 761.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable on-site disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment (i.e., drums or other containers) shall be evaluated for use as long-term storage. Also, other site conditions such as drainage control, security and soil types must be considered in order to provide proper storage.

4.0 Quality Assurance / Quality Control

A container log shall be maintained in the site Logbook. The container log shall contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample. Weekly inspections of the drum or dump box storage areas will be performed and documented in the site log.

5.0 Data and Records Management

5.1 Records associated with the activities described in this SOP, including waste disposal manifests, will be maintained according to the document management policy for the project.

5.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.0 Personnel Qualifications and Training

6.1 Qualifications and training

6.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

6.1.2 All personnel managing the handling of hazardous wastes must be trained to maintain compliance with Department of Transportation (DOT) HAZMAT shipping protocols and requirements.

6.2 Responsibilities

AECOM

Standard Operating Procedure

Headspace Screening

Procedure Number: 54230-SI-SOP-04

Revision No.: 0

Revision Date: October 2010

________________________ Date: ____________________

SOP Author

________________________ Date: ____________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

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Contents

1.0 Scope and Applicability

1.1 This SOP describes the basic techniques for using headspace analysis to screen for volatile organics in contaminated soils using a portable Photo Ionization Detector (PID) or Flame Ionization Detector (FID).

1.2 Specific project requirements as described in an approved Work Plan, Field Sampling Plan, Quality Assurance Project Plan, or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.2 This section presents the generic hazards associated with headspace screening and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific HASP will address additional requirements and will take precedence over this document. Note that headspace screening usually requires Level D personal protection unless there is a potential for airborne exposure to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with the Site Safety and Health Officer (SSHO) or Environment, Health, and Safety (EHS) Coordinator.

2.3 Health and safety hazards and corresponding precautions include, but are not limited to, the following:

- Dermal contact with contaminated soil. Personnel should treat all soil as potentially contaminated and wear chemically impervious gloves. Minimize skin contact with soil by using sampling instruments such as stainless steel spades or spoons. Do not touch any exposed skin with contaminated gloves.

- Inhalation hazards. Appropriate air monitoring should be conducted to ensure that organic vapor concentrations in the breathing zone do not exceed action levels as specified in the Site-Specific HASP. When ambient temperatures are low enough to require warming samples using the vehicle heater, the vehicle's windows should be opened enough to prevent the build-up of any organic vapors. Use the PID or FID to verify the airborne concentrations in the vehicle remain below applicable action levels. Note that many volatile organic compounds (VOCs) are flammable and all precautions must be observed to eliminate any potential ignition sources.

- Shipping limitations. Follow applicable regulations when shipping FID/PID equipment. When shipping an FID by air, the hydrogen tank must be bled dry. Calibration gas canisters are considered dangerous goods and must be shipped according to IATA and DOT regulations. Consult your EHS Coordinator and check with your shipping company to determine the correct shipping procedures.

3.0 Equipment and Materials

3.1 The following materials must be on hand in good operating condition and/or in sufficient quantity to ensure that proper field analysis procedures may be followed.

- Calibrated PID/FID instrument
- Top-sealing “Zip-Loc” type plastic bags – or – 16 ounces of soil or “mason-” type glass jars and aluminum foil
- Project field book and/or boring logs
- PPE as specified in the Site-Specific HASP
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP

4.0 Procedures

4.1 Preparation

Review available project information to determine the types of organic vapors that will likely be encountered to select the right instrument. The two basic types of instruments are FIDs and PIDs.

FIDs work well with organic compounds that have relatively lightweight molecules, but may have problems detecting halogenated compounds or heavier organic compounds; FIDs can detect methane for example. Since the FID uses a flame to measure organic compounds, ensure that work is conducted in an atmosphere, which is free of combustible vapors. If ambient temperatures are below 40°F, the flame of the FID may be difficult to light.

When using a PID, select an instrument that can measure the ionization potential of the anticipated contaminants of concern. PIDs work well with a range of organic compounds and can detect some halogenated hydrocarbons; PIDs cannot detect methane. The correct ultraviolet (UV) light bulb must be selected according to the types of organic vapors that will likely be encountered. The energy of the UV light must equal or exceed the ionization potential of the organic molecules that the PID will measure. The NIOSH Pocket Guide to Chemical Hazards is one source for determining ionization potentials for different chemicals. Bulbs available for PIDs include 9.4 eV, 10.6 (or 10.2) eV, and 11.7 eV bulbs. The 10.6 eV bulb is most commonly used as it detects a fairly large range of organic molecules and does not burn out as easily as the 11.7 eV bulb. The 9.4 eV bulb is the most rugged, but detects only a limited range of compounds. Under very humid or very cold ambient conditions, the window covering the UV light may fog up, causing inaccurate readings. Ask your EHS coordinator about correction factors when high humidity conditions exist.

After selecting the correct instrument, calibrate the PID/FID according to the manufacturer's instructions. Record background/ambient levels of organic vapors measured on the PID/FID after calibration and make sure to subtract the background concentration (if any) from your readings. Check the PID/FID readings against the calibration standard at any time when readings are suspected to be inaccurate, and recalibrate, if necessary. Be aware that, after measuring highly contaminated soil samples, the PID/FID may give artificially high readings for a time.

4.2 Top-Sealing Plastic Bag

Place a quantity of soil in a top-sealing plastic bag and seal the bag immediately. The volume of soil to be used should be determined by the project manager or field task manager. The volume of soil may vary between projects but should be consistent for all samples collected for one project. Ideally, the bag should be at least 1/10th-filled with soil and no more than half-filled with soil. Once the bag is sealed, shake the bag to distribute the soil evenly. If the soil is hard or clumpy, use your fingers to gently work the soil (through the bag) to break up the clumps. Do not use a sampling instrument or a rock hammer since this may create small holes in the plastic bag and allow organic vapors to escape. Alternatively, the sample may be broken up before it is placed in the bag. Use a permanent marker to record the following information on the outside of the bag:

- Site identification information (i.e., borehole number) Depth interval
- Time the sample was collected
- For example: "SS-12, 2-4 ft, @1425"

Headspace should be allowed to develop before organic vapors are measured with a PID/FID. The amount of time required for sufficient headspace development may be determined by the project-specific sampling plan and the ambient temperature. Equilibration time should be the same for all samples to allow an accurate comparison of organic vapor levels between samples. However, adjustments to equilibration times may be necessary when there are large variations in ambient temperature from day to day. When ambient temperatures are below 32°F, headspace development should be within a heated building or vehicle. When heating samples, be sure there is adequate ventilation to prevent the build-up or organic vapors above action levels.

Following headspace development, open a small opening in the seal of the plastic bag. Insert the probe of a PID/FID and seal the bag back up around the probe as tightly as possible. Alternatively, the probe can be inserted through the bag to avoid loss of volatiles. Since PIDs and FIDs are sensitive to moisture, avoid touching the probe to the soil or any condensation that has accumulated inside of the bag. Since the PID/FID consumes organic vapors, gently agitate the soil sample during the reading to release fresh organic vapors from the sample.

Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted. Record the highest reading on the field form or in the field notebook as described in Section 7.

4.3 Jar and Aluminum Foil (Alternate Method)

Half-fill a clean glass jar with the soil sample to be screened. Quickly cover the jar's opening with one to two sheets of clean aluminum foil and apply the screw cap to tightly seal the jar. Allow headspace development for at least ten minutes. Vigorously shake the jar for 15 seconds, both at the beginning and at the end of the headspace development period. Where ambient temperatures are below 32 ^{O}F (0 ^{O}C), headspace development should be within a heated area. When heating samples be sure there is adequate ventilation to prevent the build-up of organic vapors above action levels.

Subsequent to headspace development, remove the jar lid and expose the foil seal. Quickly puncture the foil seal with the instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates. As an alternative, use a syringe to withdraw a headspace sample, and then inject the sample into the instrument probe or septum-fitted inlet. This method is acceptable contingent upon verification of methodology accuracy using a test gas standard. Following probe insertion through the foil seal or sample injection to probe, record the highest meter response on the field form or in the field notebook. Using foil seal/probe insertion method, maximum response should occur between two and five seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted.

5.0 Quality Assurance / Quality Control

5.1 Quality Assurance/Quality Control (QA/QC) will include the collection of duplicate samples. In general, one duplicate will be collected per 20 samples. Organic vapor concentrations measured in the primary and duplicate samples should be similar within plus or minus 20 percent. The frequency of headspace duplicate collection will be determined by the project manager/task manager. The PID/FID instrument must be calibrated according to the manufacturer's instructions before beginning screening, and checked or recalibrated when readings are suspected to be inaccurate. Record ambient organic vapor levels in the field notebook and on the field form. Periodically check ambient organic vapor levels. If ambient levels have changed more than 20 percent, recalibrate the PID/FID. Make sure readings are not collected near a vehicle exhaust or downwind of the drill rig exhaust. If grossly contaminated soil is encountered, decontaminate sampling instruments between samples and/or change contaminated gloves to avoid cross contaminating less contaminated samples.

6.0 Data and Records Management

6.1 All data generated (results and duplicate comparisons) will be recorded in the field notebook and/or on the field form. Any deviation from the outlined procedure will also be noted. Field conditions (ambient temperature, wind, etc.) should also be recorded in the field notebook.

6.2 Readings may be recorded in a field notebook, on a boring log, or on an appropriate form specific to the project. The form should include the following information:

- When the PID/FID was calibrated (date/time) and calibration standard used
- Background/ambient concentrations measured after PID/FID calibration Location of sample (i.e., bore-hole number)
- Depth interval of sample measured
- Lithology of material measured
- PID/FID reading and units of measure

6.3 Note that if PID/FID measurements are recorded on a boring log, it is not necessary to duplicate information in the column where the PID/FID readings are recorded (e.g., borehole number, depth interval, lithology type).

6.4 All documentation will be stored in the project files and retained following completion of the project.

6.5 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.6 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

7.0 Personnel Qualifications and Training

7.1 Qualifications and training

7.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

7.1.2 No specialized skills are needed to perform headspace screening.

7.2 Responsibilities

7.2.1 The project manager/task manager is responsible for overseeing work activities to ensure that field screening is performed and documented in accordance with the methods described this SOP and in the project-specific field sampling plan. The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

7.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

8.0 References

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

9.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]

Standard Operating Procedure

Soil and Rock Sample Acquisition

Procedure Number: 54320-SI-SOP-01

Revision No.: 0

Revision Date: October 2010

_________________________________ Date: _________________________________

SOP Author

_________________________________ Date: _________________________________

Project Manager

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: ________ Date: ________

Initials: ________ Date: ________

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Standard Operating Procedure

Soil and Rock Sample Acquisition

1.0 Scope and Applicability

1.1 The purpose of this procedure is to describe the handling of rock cores and subsurface soil samples collected during drilling operations. Surface soil sampling also is described.

1.2 The methods described is this SOP are applicable for the recovery of subsurface soil and rock samples acquired by coring operations or soil sampling techniques such as split-barrel sampling and thin-walled tube sampling. Procedures for the collection of surface soil samples also are discussed. This SOP does not discuss drilling techniques or well installation procedures.

1.3 Thin-Walled Tube Sampler – A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outer diameter (O.D.) and 18 to 54 inches in length.

1.4 Split-Barrel Sampler – A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into unconsolidated materials using a drive weight mounted on the drilling string. A standard split-spoon sampler (used for performing Standard Penetration Tests) is two inches O.D. and 1-3/8-inches inner diameter (I.D.). This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively.

1.5 Grab Sample – An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time.

1.6 Composite samples – A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Two types of composite samples are listed below:

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.
- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes, and estuaries.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Equipment and Materials

3.1 In addition to those materials provided by the subcontractor, the project geologist/sampling engineer will require:

- Field Sampling Plan, QAPP, and HASP
- Boring log forms
- Spatula (stainless steel is recommended)
- Sample kit (bottles, labels, labeling pen/marker, custody records and tape, cooler)
- Folding rule or tape measure
- Equipment decontamination materials
- Health and safety equipment (as required by HASP)
- Field project notebook/pen

4.0 Procedures

Subsurface soil and rock samples are used to characterize the three-dimensional subsurface stratigraphy. This characterization can indicate the potential for migration of contaminants from various sites. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of subsurface soil samples. Where the remedial activities may include in-situ treatment, or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Surface soil samples serve to characterize the extent of surface contamination at various sites. These samples may be collected during initial site screening to determine gross contamination levels and levels of personal protection required as part of more intensive field sampling activities, to gather more detailed site data during design, or to determine the need for, or success of, cleanup actions.

Site construction activities may require that the engineering and physical properties of soil and rock be determined. Soil types, bearing strength, compressibility, permeability, plasticity, and moisture content are some of the geotechnical characteristics that may be determined by laboratory tests of soil samples. Rock quality, strength, stratigraphy, structure, etc. often are needed to design and construct deep foundations or remedial components.

4.1 Subsurface Soil Samples

This section discusses three methods for collecting subsurface soil samples: (1) split-spoon sampling; (2) shelby tube sampling; and (3) bucket auger sampling. All three methods yield samples suitable for laboratory analysis.

4.1.1 Split-Barrel (Split-Spoon) Sampling

The following procedures are to be used for split-spoon, geotechnical soil sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation.
- Side-discharge or bottom-discharge bits are permissible. The process of jetting through the sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.
- The two-inch O.D. split-barrel (not for geotech) sampler should be driven with blows from a 140-pound hammer falling 30 inches in accordance with ASTM D1586-84, Standard Penetration Test.
- Repeat this operation at intervals not longer than 5 feet in homogeneous strata, or as specified in the Sampling and Analysis Plan.
- Record on the field boring log form or field log book the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last one foot of penetration. (If less than one foot is penetrated, the logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24 inches, the sum of second and third six-inch increments will be used to calculate the penetration resistance. (Refusal of the Standard Penetration Test will be noted as 50 blows over an interval equal to or less than 6 inches; the interval driven will be noted with the blow count.)
- Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Describe carefully the recovery (length), composition, structure, consistency, color, condition, etc. of the recovered soil according to 54230-SI-SOP-03; then put into jars without ramming. Jars with samples not taken for chemical analysis should be tightly closed, to prevent evaporation of the soil moisture. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms (see 54230-SI-SOP-09). Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area.

In addition to collecting soils for geotechnical purposes, split-spoon sampling can be employed to obtain samples for environmental analytical analysis. The following procedures are to be used for split-spoon, environmental soil sampling:

- Follow sample collection procedures 1 through 6 as outlined in Section 5.2.1.
- After sample collection, remove the soil from the split-spoon sampler. Prior to filling laboratory containers, the soil sample should be mixed thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. Soil samples for volatile organic compounds should not be mixed and should be collected in a manner which complies with the regulatory requirements of the project.
- Record all pertinent sampling information such as soil description, sample depth, sample number, sample location, and time of sample collection in the field boring log form or field log book. In addition, label, tag, and number the sample bottle(s).
- Pack the samples for shipping and attach seal to the shipping package. Make sure that Chain-of-Custody Forms and Sample Request Forms are properly filled out and enclosed or attached (see 54230-SI-SOP-09).
- Decontaminate the split-spoon sample as described in 54230-SI-SOP-07. Replace disposable latex gloves between sample stations to prevent cross-contaminating samples.

For obtaining composite soil samples (see Section 3.0), a slightly modified approach is employed. Each individual discrete soil sample from the desired sample interval will be placed into a stainless-steel, decontaminated bowl (or other appropriate container) prior to filling the laboratory sample containers. Special care should be taken to cover the bowl between samples with aluminum foil to minimize volatilization. Immediately after obtaining soils from the desired sampling interval, the sample to be analyzed for volatile organic compounds (VOCs) should be collected. In the event that a composite sample is required, care should be taken to obtain a representative sampling of each sample interval. The remaining soils should be thoroughly mixed. Adequate mixing can be achieved by stirring in a circular fashion and occasionally turning the soils over. Once the remaining soils have been thoroughly combined, samples for analyses other than VOCs should be placed into the appropriate sampling containers.

4.1.2 Thin-Wall (Shelby Tube) Sampling

When it is desired to take undisturbed samples of soil for physical laboratory testing, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method applies:

- Clean out the hole to the sampling depth, being careful to minimize the chance for disturbance or contamination of the material to be sampled.
- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Only side discharge bits are permitted.

- Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.
- With the sampling tube resting on the bottom of the hole and the water level in the boring at the natural groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed further than the length provided for the soil sample. Allow a free space in the tube for cuttings and sludge.
- After pushing the tube, the sample should sit 5 to 15 minutes prior to removal. Immediately before removal, the sample must be sheared by rotating the rods with a pipe wrench a minimum of two revolutions.
- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of the sample again. After removing at least an inch of soil, from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a ½-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place and then dip the ends in wax to seal them.
- Affix labels to the tubes and record sample number, depth, penetration, and recovery length on the label. Mark the same information and “up” direction on the tube with indelible ink, and indicate the top of the sample. Complete chain-of-custody and other required forms (see 54230-SI-SOP-09). Do not allow tubes to freeze, and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.
- From soil removed from the ends of the tube, make a careful description using the methods presented in 54230-SI-SOP-03.
- When thin-wall tube samplers are used to collect soil for certain chemical analyses, it may be necessary to avoid using wax, newspaper, or other fillers.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Other appropriate devices can be used in conjunction with the tube samplers to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and, therefore, their use should be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt should be made with a split-spoon sampler at the same depth so that at least one sample can be obtained for classification purposes.

4.1.3 Bucket (Hand) Auger Sampling

Hand augering is the most common manual method used to collect surface and subsurface samples. Typically, 4-inch auger buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand auger extensions becomes so severe that in resistant materials powered methods must be used. When a vertical sampling interval has been established, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a decontaminated bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in material from the upper portions of the hole. The bucket auger should be decontaminated between samples as outlined in 54230-SI-SOP-07.

In addition to hand augering, powered augers can be used to advance a boring for subsurface soil collection. However, this type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sample depth, at which point a hand auger is usually used to collect the sample.

4.2 Surface Soil Samples

Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. For loosely packed surface soils, stainless steel (organic analyses) or plastic (inorganic analyses) scoops or trowels, can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand bucket auger or power soil auger may be used.

The following methods are to be used:

- Use a soil bucket auger or a scoop or trowel for surface samples, as appropriate. Remove debris, rocks, twigs, and vegetation before collecting the sample.
- Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field log book and on the sample log sheet, chain-of-custody record (54230-SI-SOP-09), and other required forms.

- Classify and record a description of the sample, as discussed in 54230-SI-SOP-03. Descriptions for surface soil samples should be recorded in the field log book or on field soil boring log form.
- Store the sampling utensil in a plastic bag until decontamination or disposal. Use a new or freshly-decontaminated sampling utensil for each sample taken.
- Pack and ship as described in 54230-SI-SOP-09.
- Mark the location with a numbered stake if possible and locate sample points on a sketch of the site or on a sketch in the field log book.
- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles should be full) should be placed in a stainless steel bucket (or other appropriate container), mixed thoroughly using a decontaminated stainless steel spatula or trowel, and a composite sample collected. In some cases, as delineated in project-specific sampling and analysis plans, laboratory compositing of the samples may be more appropriate than field compositing. Samples to be analyzed for parameters sensitive to volatilization should be composited and placed into the appropriate sample bottles immediately upon collection.

4.3 Rock Cores

Once rock coring has been completed and the core recovered, the rock core must be carefully removed from the barrel, placed in a core tray (previously labeled “top” and “bottom” to avoid confusion), classified, and measured for percentage of recovery, as well as the rock quality designation (RQD) (see 54230-SI-SOP-03). If split-barrels are used, the core may be measured and classified in the split barrel after opening and then transferred to a core box.

Each core shall be described and classified on a field boring log form using a uniform system as presented in 9903-FSP-SOP-03. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of hydrated formations) or oxidation of the core, the core must be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores must be placed in the sequence of recovery in wooden or plastic core boxes provided by the drilling contractor. Rock cores from different borings shall not be placed in the same core box. The core boxes should be constructed to accommodate 10 to 20 linear feet of core and should be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and the run number shall be marked on the wooden partitions with indelible ink. The order of placing cores shall be the same in all core boxes. The top of each core obtained should be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, any empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data pertaining to the box's contents. At a minimum, the following information must be included:

- Project name
- Date
- Boring number
- Footage (depths)
- Run number(s)
- Recovery
- Rock Quality Designation (RQD)
- Box number (x of x)

It is also useful to draw a large diagram of the core in the box, on the inside of the box top. This provides more room for elevations, run numbers, recoveries, comments, etc., than could be entered on the upper edges of partitions or spaces in the core box.

For easy retrieval when core boxes are stacked, the sides and ends of the box should also be labeled and include project name, boring number, top and bottom depths or core and box number.

Due to the weight of the core, a filled core box should always be handled by two people. Core boxes stored on site should be protected from the weather. The core boxes should be removed from the site in a careful manner as soon as possible. Exposure to extreme heat or cold should be avoided whenever possible. Arrangements should be made to dispose of or return the core samples to the client for completion of the project.

4.4 Contaminated Materials Handling

9903-FSP-SOP-14, entitled "Handling of Site Investigation Derived Waste", discusses the procedures to be used for the handling of auger cuttings, decontamination water, steam pad water, and development and purge water. Specific handling procedures should be delineated in the Field Sampling Plan. In general, all site investigation generated wastes shall be containerized unless otherwise specified by the Field Sampling Plan. The disposition of these wastes shall be determined after receipt of the appropriate analytical results.

5.0 Quality Assurance / Quality Control

Where applicable, field boring log forms and the Field Log Book will serve as the quality assurance records for subsurface soil samples, rock cores and near surface soil samples collected with a hand or power auger. Observations shall be recorded in the Field Log Book. Chain-of-Custody records shall be completed for samples collected for laboratory analysis as described in 54230-SI-SOP-08.

6.0 Data and Records Management

6.1 The records generated in this procedure are part of the permanent record supporting the associated measurements and may include, as applicable, the field boring logs, sample tags, carrier waybills, and field records of sample history (collection, handling, storage, analysis, etc.).

6.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

6.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

7.0 Personnel Qualifications and Training

7.1 Qualifications and training

7.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

7.1.2 No specialized skills are needed to perform soil and rock sample acquisition if accompanied by a Project Geologist/Engineer trained in classifying and logging soil and rock cores in accordance with 54230-SI-SOP-03.

7.2 Responsibilities

7.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

7.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

7.2.3 Project Manager – The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

7.2.4 Field Team Leader – The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in accordance with the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

7.2.5 Project Geologist/Engineer – It is the responsibility of the Project Geologist/Engineer to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The Project Geologist/Engineer is responsible for the proper acquisition of rock cores and subsurface soil samples.

7.2.6 Sampling Personnel – It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of samples.

8.0 References

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

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American Society for Testing and Materials, 1987. Standard Practice for Thin-Walled Tube Sampling of Soils. Method D1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

American Society for Testing and Materials, 1987. Standard Practice for Diamond Core Drilling for Site Investigation. Method D2113-83 (1987), Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U.S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U.S. EPA, Environmental Services Division, Athens, Georgia.

9.0 Revision History

Revision	Date	Changes
0	[month year]	[changes to be inserted]