AVX Corporation

# INVESTIGATION WORK PLAN

AVX Corporation Site
3800/3900 Electronics Drive
Raleigh, North Carolina

April 2016

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D SOP428199 – Soil Gas Sampling using Single or Nested Ports

E SOP416199 – Tracer Gas

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 2L Standards | North Carolina Administrative Code 2L Groundwater Quality Standards |
| AGI | Amplified Geochemical Imaging, LLC |
| AMEC | AMEC Environment & Infrastructure, Inc. |
| Arcadis | Arcadis G&M of North Carolina, Inc. |
| AVX | AVX Corporation |
| bgs | below ground surface |
| CAP | Corrective Action Plan |
| cis-1,2-DCE | cis-1,2-dichloroethene |
| COI | constituent of interest |
| Corning | Corning Glass Works |
| CSM | conceptual site model |
| DO | dissolved oxygen |
| DWM | Division of Waste Management |
| EDR | Environmental Data Resources |
| ESA | Environmental Site Assessment |
| GWSL | groundwater screening level |
| HASP | Health and Safety Plan |
| HQ | hazard quotient |
| HSU | hydrostratigraphic unit |
| IHSB | Inactive Hazardous Sites Branch |
| IHSB Guidance | Supplemental Guidelines for the Evaluation of Structural Vapor Intrusion Potential for Site Assessments and Remedial Actions under the NCDENR Inactive Hazardous Sites Branch |
| Law | Law Environmental |
| mg/kg | milligrams per kilogram |
| Mid-Atlantic | Mid-Atlantic Associates, Inc. |
| NCDENR | North Carolina Department of Environment and Natural Resources |
| NCDEQ | North Carolina Department of Environmental Quality |
| NCDNRCD | North Carolina Department of Natural Resources and Community Development |
| ORP | oxidation-reduction potential |

| | |
|---|---|
| PCE | tetrachloroethene |
| PDB | passive diffusion bag |
| PID | photoionization detector |
| Proctor | Proctor Environmental Services |
| PVC | polyvinyl chloride |
| PWR | partially weathered rock |
| QC | quality control |
| RAP | Remedial Action Plan |
| RQD | rock quality designation |
| site | AVX Corporation's site located at 3800/3900 Electronics Drive in Raleigh, North Carolina |
| SVOC | semivolatile organic compound |
| TCE | trichloroethene |
| TMB | trimethylbenzene |
| trans-1,2-DCE | trans-1,2-dichloroethene |
| µg/L | micrograms per liter |
| USEPA | United States Environmental Protection Agency |
| UST | underground storage tank |
| VAP | vertical aquifer profile |
| VI | vapor intrusion |
| VOC | volatile organic compound |
| WCSS | whole core soil sampling |
| Work Plan | Investigation Work Plan |

# 1 INTRODUCTION

Arcadis G&M of North Carolina, Inc. (Arcadis) has prepared this Investigation Work Plan (Work Plan) for the AVX Corporation (AVX) site located at 3800/3900 Electronics Drive in Raleigh, North Carolina (site) (**Figure 1-1**). This Work Plan has been prepared to present a scope of work necessary to further delineate the nature and extent of constituents of interest (COIs) in the subsurface soil, groundwater, and soil gas. The proposed delineation activities are designed to address data gaps identified during Arcadis' review of historical investigation and groundwater monitoring reports prepared by others. Only after addressing the identified data gaps can the historical/current remedial program, being implemented by others, be fully evaluated to assess past and future likelihood of remedial success.

## 1.1 Site Description

As described in the Phase I Environmental Site Assessment (ESA; Proctor Environmental Services [Proctor] 2015), the site includes an approximately 32.55-acre parcel (Wake County Tax Assessor Parcel Identification Number 715781482), which is partially developed with an approximately 139,000-square-foot heated manufacturing building, including administrative space (**Figure 1-2**). At the time of Arcadis' February 11, 2016 site inspection, a few other structures were noted, including a small (approximately 63 feet by 17 feet) empty concrete block former chemical storage building, small (approximately 24 feet by 20 feet) empty concrete block equipment storage/maintenance building, and small (approximately 15 feet by 25 feet) metal clad building housing the aboveground components of an operating groundwater remediation system (pumping and treatment equipment). In addition, a leveled area was observed in the southwestern quadrant of the site, which marks the location of the former research building and associated chemical storage building, which were demolished in 2011. The property is bisected by a stream that flows approximately west to east through a wooded section of the site.

According to Proctor (2015), the site was originally developed with its current primary structure in 1963. The site is located in a highly developed commercial, light industrial, and residential area in the northern part of Raleigh, North Carolina. The entrance to the site is from the north off of New Hope Church Road, north of which are two convenience stores, a commercial business park, a home and garden equipment shop, and a telephone switching station and gas station. To the east of the site, across Atlantic Avenue, is a residential neighborhood called Brentwood. To the south of the site are several office buildings occupied by the Carolina Ballet and Newcomb and Company. To the west of the site, across the Seaboard railroad tracks, are several single and multi-tenant commercial buildings consisting of light industrial and commercial businesses.

The City of Raleigh Department of Public Utilities provides municipal water and sewer to the site and area residences/commercial facilities. Historical information researched during Proctor's Phase I ESA indicates that the site was first developed at least as early as 1943, when what appears to be a farm-related structure or residence was present.

## 1.2 Site Operational History

Corning Glass Works (Corning) reportedly manufactured thin film tantalum oxide electrical capacitors at the site from 1962 until 1987, when the site and associated operations were sold to AVX. Reportedly, AVX conducted operations from 1987 until approximately 2011, and more limited operations until 2013 when production of electrical capacitors ceased. Most of the historical operations were conducted within the main building (3900 Electronics Drive), which remains standing but is vacant (**Figure 1-2**). A second large building, referred to as the "research building" (3800 Electronics Drive), was located approximately 500 feet to the south and was used for research laboratories and offices starting around 1962/1963 (based on review of building plans) (**Figure 1-2**) and the building was razed in 2011. Smaller buildings were located to the south of the main building and included a chemical storage building for virgin solvents and fuels, a small equipment and vehicle repair garage, and a remediation system operation building (**Figure 1-2**).

## 1.3 Site Environmental History

Based on Proctor's Phase I ESA (2015) and Mid-Atlantic Associates, Inc.'s (Mid-Atlantic's) Environmental Evaluation Report (Mid-Atlantic 2015) and various reports by Law Environmental (Law; 1989 and 1991) and AMEC Environment & Infrastructure, Inc. (AMEC; 2012, 2013a, 2013b, 2014, 2015), the following briefly summarizes key milestones in the site's environmental history:

- Reportedly during AVX's October 19, 1987 pre-acquisition audit of the site, an injection well, or dry well, was discovered east of the chemical storage building, with floor drains from that building where virgin solvents were stored apparently connected to the injection well.
- The above was noted in a November 12, 1987 Pollution Incident Reporting Form for Incident No. 3548, which also indicated that soil sampling in the area of the injection well revealed elevated concentrations of chlorinated hydrocarbons. Furthermore, Corning also reported the presence of this injection well in a November 20, 1987 correspondence to the North Carolina Department of Natural Resources and Community Development (NCDNRCD) (now the North Carolina Department of Environment Quality [NCDEQ]). Corning concluded that solvents were apparently released into the dry well during its 22-year operation of the facility.
- A November 25, 1987 letter from the NCDNRCD to Corning stated that injection wells are not permitted in North Carolina and that Corning must initiate steps to mitigate and assess the incident.
- According to Law (1991), a soil gas investigation was performed in November 1987, which identified elevated concentrations of COIs in soil gas samples near the dry well. The dry well was removed/disconnected from the chemical storage building in November 1987.
- As reported in the Report for Ground-Water Assessment (Law 1989), Law conducted initial assessment activities in February 1988 that were reported in a March 2, 1989 report entitled Report for Hydrogeological Characterization and Groundwater Analysis. Although this report was not available for Arcadis' review, the report apparently stated that Law performed a three boring/three monitoring well assessment in February 1988 and also delineated solvent-based contamination in soil around the dry well.

- Following the 1988 work, Law prepared conceptual engineering drawings and supporting calculations for use and planning of removal of contaminated soil from around the dry well. In May 1989, Law removed 538 cubic yards of contaminated soil from the location of the former dry well. Law also performed additional groundwater assessment activities in 1989 (Law 1989) that further described activities and findings of solvent-based COIs (trichloroethene [TCE], tetrachloroethene [PCE], trans-1,2-dichloroethene [trans-1,2-DCE], and toluene) within the stream bisecting the site and in groundwater within saprolite and partially weathered rock (PWR). The findings included discovery of TCE in groundwater sampled from a well (MW-1) approximately 100 feet upgradient from the dry well.
- On July 17, 1991, the North Carolina Department of Environment and Natural Resources (NCDENR) issued Corning a Notice of Violation and requested that Corning submit a Corrective Action Plan (CAP) and apply for a National Pollutant Discharge Elimination System discharge permit in the event that discharging extracted and treated groundwater would be necessary.
- On September 25, 1991, Law submitted a Remedial Action Plan (RAP) (Law 1991) to the NCDENR outlining specifications for a pump and treat groundwater remediation system with treated effluent discharging under permit into the City of Raleigh publically owned treatment works.
- According to AMEC (2012), the groundwater remediation system described in the RAP (Law 1991) was installed and began operation in the fall of 1992. Also according to AMEC (2012), operation of the groundwater system was intermittent, with the system not operable between July 1996 and March 1997 and then again between November 2008 and March 2013.
- In August 2013, AMEC (AMEC 2013b) installed and sampled two offsite groundwater monitoring wells (MW-13A and MW-13B) within the City of Raleigh's right-of-way along Ingram Drive. Based on the initial sampling (September 2013), bromodichloromethane was observed in groundwater sampled from monitoring well MW-13B at a concentration of 1.1 micrograms per liter (µg/L), although it was also noted that bromodichloromethane was also observed in the hydrant water, which was used for drilling makeup water at 6.2 µg/L. Based on subsequent sampling in May 2014, TCE was reported in a groundwater sample from monitoring well MW-13B at a concentration of 1.6 µg/L.
- In 2015, Mid-Atlantic (Mid-Atlantic 2015) performed an environmental evaluation of the site on behalf of a potential purchaser of the property. The evaluation included an expanded assessment of soil and groundwater quality, an assessment of sub-slab soil gas, as well as an asbestos and lead paint survey. As part of that evaluation, Mid-Atlantic performed the following:
    - Limited soil assessment mainly to the south of the main building, with one location within the footprint of the former research building and another within the footprint of the associated former chemical storage building to the north of the research building.
    - Additional delineation of COIs in groundwater through installation of monitoring wells (MW-14A, MW-14B, MW-15A, and MW-16A). Based on the results of sampling, the known width of the downgradient COI plume, specifically TCE, expanded (MW-14B), and TCE was also observed farther upgradient (MW-15A) from the dry well than had been previously documented.

- An assessment of volatile organic compound (VOC) concentrations in sub-slab soil gas. Based on the pervasive observation of concentrations exceeding residential and non-residential screening levels throughout the basement portion of the facility, it appears that other sources of VOCs are present within the footprint of the main building.
- An asbestos survey revealed asbestos-containing material in samples, primarily associated with floor tiles and mastic.
- A lead paint survey indicated that special handling would be necessary if any materials were to be stripped of lead-based paint.

- Synthesis of the above suggests that chlorinated VOCs are the primary COIs, with some metals being COIs of secondary importance. In addition, there appear to be multiple historical sources contributing to the presence of VOCs in groundwater, soil, and soil gas primarily associated with the dry well and features within and near to the footprint of the main building, but potentially other locations, based on the distribution of chlorinated VOCs in groundwater. There are also potential offsite contributions to the degradation of groundwater quality on the site.

# 2 CONCEPTUAL SITE MODEL

## 2.1 Topography and Drainage

**Figure 2-1** shows the site and the surrounding topography. The site is located within the Piedmont Physiographic Province of North Carolina, which lies between the Appalachian Mountains and the Coastal Plain. This area is characterized by undulating terrain, with 100 to 300 feet of elevation change between the ridgelines and valleys and sloping gently to the east.

The site is bisected by an unnamed stream that flows west-northwest to east-southeast across the site. This stream is relatively deeply cut with steep banks that are at least 10 feet high in places. The headwaters of the stream are to the west near St. Albans Drive. The stream flows onto the site through a culvert that enters at the western property boundary. The stream flows within its natural channel until it enters a culvert on the eastern property boundary just west of Atlantic Avenue. From this point, the stream flows through the culvert until it appears to empty into Marsh Creek approximately 1,300 feet east of the site.

The main building is located on the northern side of the unnamed stream in the area of highest elevation within the property boundary. The ground surface near the main building slopes to the south, east, and northeast, with most of the surface water directed to the south toward the unnamed creek bisecting the site. The former research building is located on the southern side of the unnamed stream on a hillside that slopes to the northeast. Surface water in this area also flows to the unnamed stream. Surface water from the site eventually flows to Marsh Creek, which is approximately 1,300 feet east of the site.

## 2.2 Regional Geology and Hydrogeology

The Piedmont is composed of crystalline metamorphic rocks. The most abundant rock types include gneiss, schist, and metamorphosed granitic rocks.

The Piedmont geology is typically divided into three hydrostratigraphic units (HSUs) to describe the hydrogeology: fractured crystalline bedrock overlain by PWR and saprolite. Soils that comprise the saprolite are composed of reddish clayey to sandy silts formed by the in-situ chemical weathering of the underlying bedrock. Composition of the saprolite varies based on the parent rock that is being weathered. The weathering profile of the saprolite commonly grades from clay rich soils at shallower depths, to soils containing a high percentage of sand and gravel-sized grains near the transition to PWR.

PWR is a less weathered transitional layer between the saprolite and fractured bedrock and consists of coarser material, such as angular gravel- and cobble-sized rock remnants. It is formed by the same processes that eventually create saprolite, but it represents an earlier stage of the bedrock weathering process. The prevalence of coarser gravel- and cobble-size rock fragments increases with depth and often there are layers of intact, albeit highly weathered rock sandwiched between layers of highly fractured gravel-sized rock.

The fractured bedrock from which the other two HSUs are derived is below the PWR. The prevalence and nature of fractures is an important characteristic of this HSU because they are the primary pathway for groundwater flow and migration of COIs. The fracture density is greatest near the rock-PWR transitional boundary; the fracture density decreases with depth.

LeGrand (1954, 1967, 2004) and Heath (Heath 1984, 1988) summarize the Piedmont Hydrogeologic Province. **Figure 2-2** illustrates a typical groundwater flow system in the Piedmont (LeGrand 2004), which is described as a two-part aquifer system. The unconsolidated saprolite comprises the upper or surficial aquifer, which overlies the bedrock aquifer. The saprolite aquifer serves as the principal storage reservoir for the bedrock aquifer. The site-specific conceptual site model (CSM) further subdivides the saprolite of LeGrand into a more completely weathered rock (saprolite) and the transitional zone (PWR) between the saprolite and bedrock, because the hydraulic characteristics of the PWR can be significantly different from the overlying, fully developed soil and the underlying, largely unweathered rock.

This Piedmont hydrogeologic system possesses unique features that control groundwater flow. The potentiometric surface typically mimics the topography, and groundwater flow typically mimics surface-water drainage. Topographic highs (the upland ridges and hilltops) act as the principal areas of groundwater recharge. Perennial streams represent discharge boundaries where groundwater flows to the surface, as diffuse seepage or from springs. Groundwater, similar to surface water in the Piedmont, flows from hilltop areas to the nearest streams, marshes, or wetlands within the same drainage basin.

Perennial Piedmont streams can be shown to be discharge barriers that capture all local groundwater based on three mechanisms. First, the streams will usually gain flow downstream, as streams within the Piedmont typically do not recharge groundwater. Second, groundwater flows to the stream from both sides of the valley. Third, there is an upward hydraulic gradient into the streams, further illustrating that the streams typically capture the deeper groundwater from both sides of the watershed. Based on the above mechanisms, each perennial stream acts as a drain for all groundwater within the drainage basin.

## 2.3 Site Geology and Hydrogeology

The site is located on the Raleigh Gneiss; a weakly to moderately foliated biotite-bearing granitic orthogneiss (Speer et al. 2003), shown on **Figure 2-3**. Foliations in this area dip from east to east-southeast at 75 to 90 degrees. Diabase dikes are a common occurrence in this part of the Raleigh Gneiss, with an expected orientation parallel to the foliations.

Boring logs were recorded as part of historical investigations at the site. The boring logs were evaluated to confirm that each of the monitoring wells was identified in the correct lithologic interval. No boring/well completion log was available for monitoring wells MW-1B and MW-2. The location of the existing monitoring wells is provided on **Figure 1-2**. Evaluation of the historical logs found that the hydrostratigraphic framework is consistent with the generalized Piedmont conditions described above. **Table 2-1** provides the construction details of each well and the HSU it monitors. The general characteristics of the HSUs are summarized below.

### 2.3.1 Saprolite

Saprolite at the site, formed by the in-situ weathering of the underlying metamorphic bedrock, is characterized as clay-rich soils that become sandier with depth. The base of the saprolite unit has been defined as the stratigraphic interval where the lithology transitions from fine-grained soils of primarily silt and clay-sized grains to a lithology dominated by coarser-grained sands and fragments of PWR, with a lower percentage or absence of fine-grained materials. The base of the saprolite can also be defined as refusal of a split-spoon soil sampler.

The saprolite tends to be thicker and more developed at higher elevations away from the unnamed stream and thinner and less well developed at lower elevations near the unnamed stream. Saprolite was found to be 50 feet thick at monitoring well MW-10B and 60 feet thick at monitoring well MW-3C (Law 1989), both of which are at higher elevations away from the unnamed stream. Closer to the unnamed stream, saprolite was 40 feet thick (monitoring well MW-5B) and 10 feet thick (monitoring well MW-9B) (Law 1989, 1991).

The fine-grained nature of the saprolite generally leads to lower permeability than PWR and fractured bedrock. The permeability data available for the site was derived from slug tests performed at monitoring wells screened within the saprolite. The hydraulic conductivity ranged from $10^{-3}$ to $10^{-5}$ centimeters per second (Law 1989). This range is consistent with the composition of the saprolite across the site; clayey/silty sands to sandy/silty clays.

### 2.3.2 Partially Weathered Rock

The PWR, primarily composed of sand, gravel, and cobble-sized weathered rock fragments, is a transition of two HSUs with different physical characteristics that function as one HSU. The upper portion of the PWR, near the saprolite/PWR interface, is mostly medium to coarse sand and larger weathered rock fragments. The grain size and percentage of rock present in the PWR increases with depth until it is composed entirely of highly fractured and weathered bedrock. Within the PWR, the relative degree of weathering declines with depth until the top of the competent bedrock is encountered.

The top of the PWR is defined using split-spoon refusal (i.e., 50 blows over less than 6 inches), hollow-stem auger refusal, and/or visual observations of key characteristics, such as a predominance of coarse-grained material and weathered rock fragments.

The base of the PWR HSU is defined as the transition from highly fractured/weathered bedrock to competent bedrock. For boreholes drilled using rock coring methods, rock quality designations (RQDs) less than 75% with poor recovery are still considered PWR. Monitoring well MW-3C, with an RQD of 10%, was likely installed near the base of the PWR. In the absence of this data, the transition into fractured bedrock is determined based on observations recorded during the drilling and installation of the well. Based on this definition, there are only two wells that have been drilled completely through the PWR into fractured bedrock: monitoring wells MW-13B and MW-14B.

### 2.3.3 Fractured Bedrock

The bedrock descriptions provided in the logs for monitoring wells MW-3C (which was completed at the PWR-Fractured Bedrock interface), MW-13B, and MW-14B are consistent with the formation that was mapped in this area, the Raleigh Gneiss. The description of the Raleigh Gneiss is a weakly to moderately foliated biotite-bearing granitic orthogneiss (Speer et al. 2003). Foliations have been mapped in the area, with an approximate north-northeast to south-southwest orientation and dip to the east-southeast at 75 to 90 degrees. Diabase dikes are a common occurrence in this part of the Raleigh Gneiss, with an expected orientation parallel to the foliations. At least one such feature was observed onsite in the channel for the unnamed stream.

The transition into fractured bedrock is defined by RQD classifications of greater than 75%, as for monitoring well MW-13B. In the absence of this data, as for monitoring well MW-14B, the bedrock

interface was determined based on observations recorded during the drilling and installation of the well. The depth of the PWR-fractured bedrock interface in the Piedmont is subject to localized lithologic variations and fracture zones. However, its generally deeper higher up in the watershed where saprolite and PWR are thicker and more well developed (e.g., monitoring well MW-3C where bedrock is at least 105 feet below ground surface [bgs]), and shallower at lower elevations where the saprolite and PWR are thinner (e.g., MW-13B and MW-14B where fractured bedrock is 55 feet bgs).

### 2.3.4 Groundwater Flow

Review of the available historical data in the context of typical Piedmont conditions has allowed refinement of the CSM and an improved understanding of the hydrogeologic framework that controls transport of COIs. Hydrogeology at the site appears to conform to the LeGrand model.

The site lies almost entirely within the watershed drained by the unnamed stream. Past interpretations of water-level data from the monitoring well network indicates that groundwater flow is approximately parallel to the unnamed stream. Because groundwater is interpreted to discharge to the unnamed stream based on how groundwater flows in the Piedmont and because COIs appear in surface water (see Section 2.4), the prior interpretations of groundwater flow direction is likely oversimplified in that those interpretations do not appear to consider the effect of the unnamed stream on groundwater flow.

## 2.4 Nature and Extent of Site-Related Constituents of Interest

### 2.4.1 Constituents of Interest

#### 2.4.1.1 Primary Constituents of Interest

Site COIs were determined by evaluating the most recent soil, groundwater, and vapor intrusion (VI) testing results. These constituents should be evaluated further. Based on past data, the following constituents are the primary COIs. They have been found in both groundwater at concentrations above the North Carolina Administrative Code 2L Groundwater Quality Standards (2L Standards) and in sub-slab air samples at concentrations above the NCDEQ Division of Waste Management (DWM) Non-Residential VI Screening Levels for sub-slab air (Mid-Atlantic 2015).

- TCE
- PCE
- trans-1,2-DCE/cis-1,2-dichloroethene (cis-1,2-DCE)

#### 2.4.1.2 Secondary Constituents of Interest

The following constituents are considered secondary COIs; they were identified in no more than three (out of 40) sub-slab air samples above the NCDEQ DWM Non-Residential VI Screening Levels (Mid-Atlantic 2015) and were not detected above 2L Standards in groundwater:

- Chloroform
- Dichlorodifluoromethane (Freon 12)

- 1,2,4-trimethylbenzene (TMB)
- Metals – primarily barium, which was reported in one soil sample above health-based remediation goals, and silver, which was reported in three samples at concentrations above the protection of the groundwater remediation goal (Mid-Atlantic 2015)

### 2.4.2 Potential Onsite Sources

#### 2.4.2.1 Dry Well and Chemical Storage Building

Previous investigations have identified the chemical storage building and the former dry well, south of the main building, as likely sources of COIs. Drums containing industrial solvents were kept in the chemical storage building. No specific spills were recorded, but a spill response plan put in place in the early 1970s did not require documentation of spills of quantities less than 55 gallons be recorded (Law 1989). The building floor drain (or drains) was connected to a dry “injection” well (dry well) approximately 25 feet east of the building. Spills that reached the floor drain would have been directed into the dry well (Law 1989).

The dry well was removed in 1987. Additionally, 538 tons of soil around the dry well were excavated in 1989 after nearby soil samples identified the presence of organic solvents. The extent of the excavation was determined in accordance with the guidelines provided by the North Carolina Department of Environmental Management and Division of Health Services (a precursor to the NCDEQ) to include soils with non-halogenated solvent concentrations in excess of 100 milligrams per kilogram (mg/kg) and halogenated solvent concentrations in excess of 1 mg/kg.

There were no COIs detected in the soil samples most recently collected in the area around the dry well and chemical storage building (Mid-Atlantic 2015). The soil sample locations and analytical results are provided in **Appendix A**. However, the highest concentrations of COIs in groundwater are still found in this area of the site, as well as the downgradient areas towards the unnamed stream, which suggests that this area still serves as a continuing source of COIs in groundwater.

#### 2.4.2.2 Main Building

Wastes generated onsite included halogenated solvents, non-halogenated solvents, electroplating waste, lead waste, non-listed ignitable waste, non-listed corrosive waste, ethyl acrylate, methyl methacrylate, and waste oil (Mid-Atlantic 2015).

Sub-slab air samples were collected from under the building and analyzed for VOCs. Several COIs were identified with concentrations exceeding the NCDEQ DWM screening levels for non-residential indoor air, including TCE, PCE, cis-1,2-DCE, chloroform, Freon 12, and 1,2,4-TMB (Mid-Atlantic 2015). The approximate sample locations and analytical results are provided in **Appendix B**. The highest concentrations were observed beneath the basement portion of the building (Mid-Atlantic 2015). This data suggest the soils, and possibly groundwater, below the main building slab may be a source of COIs. However, distribution of COIs in sub-slab vapor may not be directly mapped to their distribution in soils below the building floor. If soils below the building have contained COIs, those soils may be or could become a future source of COIs in groundwater after the building is demolished.

#### 2.4.2.3 Former Research Building

The former research building and associated chemical storage building has had little assessment performed.

Mid-Atlantic (2015) collected a few soil samples that showed little evidence of COIs in soil and performed no groundwater assessment. There were no COIs detected above 2L Standards in the nearest downgradient wells (MW-7B and MW-8B), but they are not optimally located to intercept groundwater containing COIs migrating from the former research building. Therefore, it is concluded that the soil and groundwater data in the area of the former research building is not adequate to conclude whether the former research building can be ruled out as a source of COIs.

### 2.4.3 Potential Offsite Sources

Proctor (2015) identified several potential offsite environmental concerns through an Environmental Data Resources (EDR) Radius Report. These are located to the west, topographically and hydraulically upgradient of the site. They include the following:

- **3711 Tar Heel Drive** – According to Proctor (2015), this location is listed as a low-priority leaking underground storage tank (UST) site from 1992, with both soil and groundwater contamination. Regulatory comments indicate that a site assessment and CAP have been submitted and that the tank area needs to be further assessed. This property is located southwest of the site. If offsite COIs were to migrate from this property onto the site via groundwater, they would likely be discovered near the former research building.
- **3816, 3900 Tar Heel Drive and 1815 and 1818 Saint Albans Drive** – These properties are identified by EDR as “Historical Auto Stations”, located adjacent to or nearby and topographically upgradient of the site. According to Proctor (2015), this is a listing of potential gasoline station sites that might, in the opinion of EDR, include service station establishments but with no record of releases/incidents. Based on Arcadis’ windshield survey of the surrounding properties, this group of identified properties appears to be a cluster of auto repair facilities. If offsite COIs were to migrate from these properties onto the site via groundwater, they would likely be discovered near the parking lot to the west of the site’s main building.
- **1904 New Hope Church Road, Star Flite #52** – This soil and groundwater contamination leaking UST site from 1991 (Incident No. 6896), located adjacent to the site’s northwestern corner, across the Seaboard Railroad tracks. The EDR report indicates that this location is considered an intermediate risk. If offsite COIs were to migrate from this property onto the site via groundwater, they would likely be discovered near the northwestern corner of the site.

In addition to the above, an active gasoline service station was noted immediately across New Hope Church Road to the north of the site. It appears that this gasoline service station is located on the opposite side of the expected topographic and hydraulic divide that likely runs east-west along New Hope Church Road near the site.

### 2.4.4 Soil Quality

Historical investigations have identified COIs in soil onsite. Reportedly, COIs in soil were identified around the former dry well prior to excavation of that area in 1989 (Law 1989). Soil data was collected in 2015 on the southern side of the main building at 13 locations between 1 and 15 feet bgs, including several locations around the former chemical storage building and dry well. At one of those locations near the eastern side of the chemical storage building (SB-11), PCE was detected at a concentration of 0.0078 mg/kg (Mid-Atlantic 2015). This is below the NCDEQ Inactive Hazardous Sites Branch (IHSB) Health Based Residential Soil Remediation Goal (16 mg/kg), but above the IHSB Protection of Groundwater Soil Remediation Goal (0.005 mg/kg). Otherwise, all VOCs, including the other COIs, were either not detected or detected below the above screening levels.

Near-surface soil samples (0 to 1 feet bgs) were also collected and analyzed for various metals in 2015. Barium was detected at one location (SSM-7) near the surface (0 to 1 feet bgs) on the southern side of the main building at a concentration of 4,300 mg/kg, which exceeds both the IHSB Health-Based and Protection of Groundwater Soil Remediation Goals (3,000 and 580 mg/kg, respectively).

There has been only one near-surface soil sample collected on each of the northern, eastern, and western sides of the main building (Mid-Atlantic 2015), and no soil samples have been collected below it. The distribution of COIs found in sub-slab soil gas samples indicates that COIs may be present at various locations in soils and possibly groundwater beneath the main building.

### 2.4.5 Groundwater Quality

Groundwater investigations and monitoring have, to date, been focused south and southeast of the main building. In this area, groundwater is expected to flow to the south to southeast. The most recent groundwater monitoring event was completed in November 2014 (AMEC 2015). The results of this event are the basis of the current understanding of the presence and distribution of COIs in groundwater. The analytical results from this event are included in **Appendix C**. To date, all groundwater investigation and monitoring has been focused on the area between the main plant and the unnamed stream. There has been no investigation of COIs in groundwater on the eastern, western, and northern side of the main building. Therefore, groundwater conditions in those areas are unknown.

The distribution of TCE with the current monitoring well network is shown on **Figure 2-4**. TCE is the most widely distributed constituent, and at every location where PCE and cis-1,2-DCE exceed the 2L Standards (0.7 µg/L and 70 µg/L, respectively), TCE (2L Standard = 3 µg/L) also exceeds it. Therefore, this constituent was used to define the extent of COIs within the current monitoring well network. The COIs detected in groundwater thus far at the site include all the primary COIs: PCE, TCE, and cis-1,2-DCE.

#### 2.4.5.1 Horizontal Distribution of Constituents of Interest

The highest concentrations of dissolved COIs were reported from water sampled from monitoring well MW-3A (TCE = 2,400 µg/L). MW-3A is downgradient of the chemical storage building and dry well. However, COIs were also identified on the upgradient side of the chemical storage building and dry well at monitoring wells MW-1A and MW-15A. This suggests it is likely that there are additional source areas, as described in Section 2.4.2.

Available data indicates that the extent of COIs exceeding the 2L Standards in groundwater is defined to the west, southwest, south, and southeast by monitoring wells MW-11A, MW-11B, MW-7B, MW-8B, MW-13A, and MW-13B. However, the 2L Standards for PCE and/or TCE are exceeded to the northwest at monitoring well MW-15A and to the northeast at monitoring wells MW-10A, MW-10B, MW-14A, and MW-14B. If there are COIs in groundwater that are derived from the main plant, then the extent of exceedances has not been evaluated on its northern and eastern side.

Although perennial streams in the Piedmont commonly act as hydraulic barriers to groundwater flow and COI transport, TCE was reported in groundwater sampled from monitoring well MW-6B (520 µg/L), which is located on the opposite side of the unnamed stream. This may be due to at least two of the recovery wells (i.e., RW-6 and RW-10) capturing groundwater and COIs from the northern side of the unnamed stream. It is possible that the source of the COIs at MW-6B could also be the research building and/or the associated chemical storage building.

#### 2.4.5.2 Vertical Distribution of Constituents of Interest

Near the main building, the highest concentrations of COIs are observed in shallower saprolite monitoring wells MW-1A and MW-3A. At downgradient locations, the highest concentrations are found in the PWR (monitoring wells MW-5B and MW-9B). This is consistent with the Piedmont conceptual model, where the saprolite acts as a storage reservoir and most lateral migration occurs in the PWR and fractured bedrock where the permeability is higher.

Only two monitoring wells have been installed in fractured bedrock, MW-13B and MW-14B, both of which are located downgradient of the source area(s). Both TCE and PCE were found at MW-14B at concentrations of 280 µg/L and 2.2 µg/L, respectively. Bromodichloromethane was the only constituent detected in groundwater from monitoring well MW-13B (1.1 µg/L) after it was installed (AMEC 2013b). Subsequent data collected by AMEC (2014) indicates that TCE was also observed in groundwater sampling in MW-13B at 1.6 µg/L in a sample collected in the second quarter of 2014. Data collected at monitoring well MW-3C (TCE = 900 µg/L), which was likely installed near the top of fractured bedrock, suggests COIs are present in fractured bedrock in this area as well. These data indicate that COIs are present in fractured bedrock. However, the limited number of wells in the fractured bedrock does not provide enough information to assess the distribution of COIs in this HSU.

The data collected to date onsite suggest that the mass distribution is consistent with the Piedmont hydrogeologic model. The highest concentrations of COIs are present in the saprolite near the source area(s). COIs migrate vertically downward to the PWR and to a lesser extent, to the underlying bedrock where fracture pathways exist. In the PWR and fractured bedrock, the COIs migrate downgradient and toward the unnamed stream, where they are discharged. The presence of COIs in surface water further support groundwater discharge at these locations.

### 2.4.6 Surface-Water Quality

Surface-water samples have historically been collected at an upstream location (Electronics Drive) and downstream location (Atlantic Avenue). In November 2014, no COIs were detected at the upstream location, but TCE was detected above its 2L Standard at a concentration of 50 µg/L at the downstream location.

The above data indicates that TCE is discharging to the unnamed stream between the upstream and downstream locations, at one or more discrete locations. Other COIs may also discharge to the unnamed stream and volatilize prior to the downstream sample location. The two current sample locations do not indicate whether other COIs discharge to the unnamed stream or where along it they discharge.

### 2.4.7 Sub-Slab Soil Vapor Quality

A discussion of available data is provided in the potential onsite source discussion as that discussion relates to the main building (Section 2.4.2.2). That data, collected by Mid-Atlantic (2015), is summarized in **Appendix B**. What is most important about the sub-slab soil vapor data is that it points to one or more potential sources of VOCs beneath the footprint of the main building. The sub-slab soil vapor data is not otherwise relevant to this investigation, as the main building and nearby outbuildings are scheduled for demolition in the upcoming months.

## 2.5 Potential Exposure Pathways

There are three primary potential COI exposure pathways identified based on historical data and the site inspection. These potential exposure pathways include the following:

- Groundwater via consumption or direct contact
- Surface water through direct contact
- VI via inhalation

It is not clear whether there could be a completed pathway for human exposure to COIs in groundwater based on review of reports by others, namely the recent investigation reports from Proctor (2015) and Mid-Atlantic (2015). Although it appears that all commercial and residential properties are provided public water by the City of Raleigh, Department of Public Utilities, we have not yet confirmed whether there are any potable water supply or irrigation wells in the area.

Surface water is a potentially complete exposure pathway onsite, based on our understanding of COI concentrations in historical surface-water samples. It is unclear whether those concentrations attenuate before reaching the nearest offsite location of potential exposure.

Although VI could be a direct contact exposure pathway in facility structures, those structures will be demolished, thereby removing that pathway. Future potential exposure pathways via VI into hypothetical future structures should be considered when considering redevelopment options. Potential offsite vapor pathways could be complete based on elevated concentrations of volatile COIs in groundwater at the downgradient property boundary in proximity to offsite residential areas.

All the above represent data gaps that are identified in Section 2.6, and for which a plan for investigation is presented in Section 3.

## 2.6 Data Gaps

Development of the CSM has led to the identification of data gaps that need to be addressed to complete the site characterization. The data gaps will be addressed during investigation activities (Section 3) to further refine the CSM. These data gaps include the following:

- Confirmation of the suite of the site COIs
- Characterization of the location and extent of potential source areas, including:
    - Beneath footprint of the main building
    - Within the footprint of the research building
    - Within the footprint of the chemical storage building associated with the main building and the former chemical storage building associated with the former research building
    - Better definition of the hydrostratigraphic framework
    - Extent of COIs in groundwater related to identified source areas
    - Characterization of the groundwater, VI, and surface-water exposure pathways

A plan to address these data gaps is presented in Section 3.

# 3 INVESTIGATION PLAN

Historical investigations have focused on the dry well as a source and lead to the implementation of corrective actions that included soil excavation near the dry well and installation of the groundwater pumping/COI containment system. However, both historical and more recent data suggests that additional source areas are likely present, although have not been fully assessed. On this basis, Arcadis is recommending a more holistic approach to the proposed investigation.

The proposed investigative approach begins with the development of the CSM and identification of the data gaps (Section 2). This Work Plan, when implemented, is designed to address the identified data gaps by using an adaptive investigation approach that will rely on a sequenced series of characterization tasks. Portions of the investigation will use high resolution soil and groundwater sampling techniques to provide a better representation of the extent of identified source zones, groundwater flow, and COI transport pathways. The ability to correlate the high resolution concentration data with the hydrostratigraphic framework will provide a robust CSM that identifies the areas of COI mass storage and zones of COI mass transport. Understanding these key elements will allow for the development of a focused remedial strategy.

The data collected during this investigation will be analyzed and evaluated in near real-time, where applicable, to provide a basis for informed decision-making as the investigation progresses. The adaptability in this type of investigation will allow the data to dictate the areas that need to be investigated, and therefore, will be far less arbitrary in determining placement of wells or soil borings to assess soil and water quality in relation to site hydrostratigraphy.

The investigation outlined in this section will begin with tasks that can be completed independent of the building demolition or any other site activities. These tasks include groundwater sampling from existing wells, surface-water sampling, downgradient soil gas sampling to evaluate potential VI pathways, and soil vapor screening to evaluate potential sources in the former research building area. Concurrent with the initial phase of investigation, it is anticipated that demolition of the main building will be completed. The data compiled during the initial phase of investigation and data collected from beneath the newly exposed footprint of the main building will greatly improve the understanding of the source(s) and source locations. After the source zones are defined, the investigation will focus on delineating the downgradient extent of COIs in groundwater and understanding the COI migration pathways. The final step in the process may include installation of a select few targeted monitoring wells to provide monitoring locations that can be used to evaluate temporal changes in groundwater quality.

## 3.1 Site Inspection

Arcadis personnel performed a site inspection on February 11, 2016, which included a walkthrough of the interior of the main building and associated out-buildings, as well as an inspection of the remaining property, including the location of the former research building, the property perimeter, and the perennial stream channel that bisects the site. The inspection also included a windshield survey of the surrounding properties, with particular attention paid to downgradient properties to the east and properties to the north and west that could potentially be offsite contributors to degradation of onsite groundwater quality.

## 3.2 Health and Safety Plan

A Health and Safety Plan (HASP) will be developed in accordance with 29 Code of Federal Regulations 1910.120 and Arcadis' corporate health and safety program and policies prior to field implementation of this Work Plan. Subcontractors will also be required to develop their plan or operate under Arcadis' HASP.

## 3.3 Utility Clearance

The presence and location of utilities will be investigated and cleared to the extent feasible by locating, marking, and, where appropriate, visually verifying (potholing) before the start of any subsurface intrusive work. Steps to be performed will include:

- Contacting the North Carolina dig safe service (North Carolina 811) to obtain a public utility mark-out.
- Consulting facility drawings and discussing with personnel that may know where underground utilities are located.
- Looking and noting field evidence of utilities (e.g., patched trenched areas and utility markers).
- Performing a private utility mark-out by using of radio frequency, radar, and/or magnetometer surveying equipment, as appropriate.
- Soft digging, via hand auger, to 5 feet bgs ahead of any borehole to be advanced using power-assisted equipment.
- Completing a utility clearance checklist before initiating power assistance subsurface investigations.

## 3.4 Soil Investigation (Phases 1 and 2)

Soil investigation activities will be divided in to two phases. The first phase will include a grid or transect approach to collect screening level data across a broad area in the areas of the main building and research building. The data from this first phase will provide the basis for identifying the number and location of additional samples to be collected during the next phase of the investigation. The data collected during Phase 2 will be used to define the nature and extent of the COIs in soil based on evaluation of Phase 1 data. Details on both phases are included below.

### 3.4.1 Main Building Area (Phase 1)

The soil investigation in the main building area will start after demolition is completed and the building slab is removed. This initial investigation will be completed using a two-step process, first to assess the entire building footprint and then focus on areas where the screening level data indicate the need for additional sampling. Details on both steps are included below.

Arcadis will work closely with the demolition contractor to perform a quick visual assessment of the building slab, before it is removed, and the soil, immediately after it is removed. In addition, key features observed within the floor slab will be surveyed, including, but not limited to, sumps and floor drains.

After the concrete slab has been removed and the soil has been visually inspected, a 10-foot by 10-foot sampling grid will be placed across the former building footprint and the soil will be screened at those grid locations. Small holes will be created with a fiberglass or steel rod to approximately 6 inches below residual sub-base material and into native soil. The intake of a photoionization detector (PID) will be placed in the hole, and the top of the hole will be temporarily plugged. PID vapor concentrations will be measured for at least 10 seconds to assess for the presence or absence of VOCs. The results of this screening will be summarized and evaluated to determine areas for follow-up soil sampling.

Soil sampling will be completed in areas where elevated PID readings indicate the presence of VOCs beneath the building. The number of borings will be based on the conditions observed during the initial screening, but is anticipated to include approximately 50 soil borings arranged on an approximate 50-foot by 50-foot grid (**Figure 3-1**). The soil borings will be advanced via hand-auger to approximately 2 feet bgs. The locations of select soil samples may be biased toward locations where higher PID screening values were observed and will be adjusted based on field conditions.

During the soil sampling, the field scientist will continually screen soil cuttings with a PID and inspect the cuttings for visual evidence of VOCs. One soil sample will be collected from each boring location at a depth near to the bottom of the boring or from the interval that elicits the highest PID reading, whichever is shallower. Samples will only be collected of the native underlying soil.

Soil samples will be placed in appropriate laboratory-provided sample containers and placed on ice and shipped via overnight courier to TestAmerica Laboratories in Savannah, Georgia for VOC analysis via United States Environmental Protection Agency (USEPA) SW-846 Method 8260 and metals (13 priority pollutant metals + barium + tin). Additional locations may (anticipated not to exceed 10) may also be assessed for semivolatile organic compounds (SVOCs) (Method 8270) based on observations of staining or elevated PID readings in the subslab soil.

### 3.4.2 Research Building Area (Phase 1)

The initial screening near the research building area will be completed using a passive soil gas investigation to determine areas where additional soil sampling is needed. This approach was selected in this area over the PID method proposed for the main building, as the footprint of the former building has been exposed since 2011. Exposure to precipitation and heat over that period of time will act to degrade and/or flush the shallow VOCs that may be present in soil. The passive soil gas method is more sensitive and can detect areas where residual VOCs may still be present.

The passive soil gas investigation will be completed using Amplified Geochemical Imaging, LLC (AGI) samplers. These samplers include a small, flexible, plastic membrane that contains an adsorbent media to sorb a variety of VOCs. The adsorbent media in the sampler is protected by an inert microporous membrane constructed using polytetrafluoroethylene (i.e., Gore-Tex®), which has relatively large pore diameters (approximately 1,000 times larger than VOC molecules). This feature makes the sampler very porous and relatively transparent to vapor but allows it to remain hydrophobic, keeping the adsorbent media clean and dry.

The AGI samplers will be deployed in transects along the footprint of the former research and chemical storage buildings. Four transects are planned across the footprint of the research building and one transect near the former chemical storage building, as shown on **Figure 3-1**. The samplers will be spaced

50 feet apart along the transects, with approximately 28 samplers deployed. The samplers will be deployed by augering a small-diameter hole (approximately 1-inch) to 3 feet bgs. The sampler will be deployed at the base of the hole and attached via string to a cork that will plug the surface. The surface location will be marked with a stake for identification during retrieval. The samplers will remain in place for up to 14 days to allow for sufficient exposure to the subsurface.

The samplers will be collected and placed in laboratory-supplied sample vials and sealed for shipment to AGI in Newark, Delaware. Laboratory analysis of the AGI samplers will be conducted by a modified USEPA Method 8260. The results will be reported in micrograms, which corresponds to the amount of mass adsorbed to the sampler. This qualitative result will allow areas of elevated VOCs to be identified and targeted during subsequent soil sampling.

### 3.4.3 Site-Wide Source and Extent Investigation (Phase 2)

Screening data collected during the Phase 1 activities will be used to refine the approach for the source investigation. The term source zone, for purposes of this Work Plan, has been defined as any area where historical releases may have occurred, resulting in soil containing COIs that can contribute to dissolved COIs in groundwater. The potential for elevated concentrations to be encountered during a source investigation facilitates the need for a more conservative approach during site characterization. The whole core soil sampling (WCSS) methodology will be used because it reduces the risk of mobilizing COIs encountered throughout the vertical extent of the borehole and allows for sample collection on fine vertical resolution. The anticipated areas for the WCSS borings are defined on **Figure 3-1**. The starting points in each area will be based off of the Phase 1 results.

The WCSS will be completed using sonic drilling techniques. At each location, the boring will be cleared from ground surface to 5 feet deep using soft digging methods (i.e., hand auger) to clear underground utilities. Continuous soil cores will then be collected at each location. The depth will vary based on soil observations and the nature of VOC analytical results generated by the mobile laboratory. At a maximum, the borings will extend in to the PWR HSU, but are not anticipated to extend into the deeper PWR, as it transitions from unconsolidated material to larger fragments of rock. The anticipated maximum depth of the borings will vary based on location but should likely not exceed 60 feet.

After the soil cores are removed from the core barrel, they will be visually inspected, scanned with a PID at 1-foot intervals, and the lithology at each location will be photographed and logged. Samples will be collected at an average frequency of one sample for every 2 feet of core. The sampling interval will be adjusted as necessary based on the observations in the field and the PID readings. Laboratory analysis will be completed using either an onsite mobile laboratory or shipped offsite to a standard laboratory. A decision on the chosen list of laboratory analytes will be made based on the Phase 1 results and the number of areas identified for further investigation.

Soil will also be collected to assess the physical properties of the soils encountered in the identified source areas. These samples will be collected at two locations vertically for an anticipated total of four samples. The samples will be sent to the Arcadis Geotechnical Laboratory in Kennesaw, Georgia and tested for physical properties (bulk density, grain size, moisture content, and Atterberg limits). TestAmerica Laboratories in Savannah, Georgia will also perform fraction organic carbon analysis. These data, in conjunction with the soil analytical data, will be used to further evaluate the characteristics of the source zones.

At the completion of each location, the boring will be immediately abandoned. Abandonment will be completed by adding neat Portland Type 1 cement to the borehole as the sonic tooling is removed. This procedure allows for the entire borehole to be abandoned and will greatly reduce the potential for downward migration of any COIs present throughout the vertical boring extent.

## 3.5 Groundwater Investigation (Phase 1 and 2)

### 3.5.1 Comprehensive Groundwater Sampling (Phase 1)

A comprehensive groundwater monitoring event will be completed to assess the current groundwater quality. All site monitoring and recovery wells and the offsite well pair (monitoring wells MW-13A and MW-13B) will be sampled (according to the procedure described below), surveyed to the North American Datum of 1983 datum, and have the depth-to-water gauged. This data will be used to evaluate groundwater flow and COI distribution and identify additional data gaps, which will be addressed in the follow-up groundwater investigation activities.

#### 3.5.1.1 Groundwater Sampling Procedure

Groundwater sampling methods will be consistent with the USEPA Region 4-approved methods, and consist primarily of low-flow/low volume techniques using peristaltic or bladder pumps for samples collected from monitoring wells. The monitoring wells will be purged with flow rates between 200 and 500 milliliters per minute. Groundwater samples from recovery wells will be collected by either collecting a sample with a drop tube using a peristaltic pump (and reverse flowing into the sample containers) or sampled directly from a sample port in the discharge line on each recovery well.

Water quality indicator parameters will be measured throughout purging using a YSI 556 Water Quality Monitor (or equivalent) equipped with a flow-through cell. This instrument will provide real-time measurements of temperature, specific conductivity, pH, oxidation-reduction potential (ORP), and dissolved oxygen (DO) of the purge water as it is pumped to the surface. Turbidity readings will be measured with a LaMotte 2020 (or equivalent). The gradual stabilization of select parameters during purging will indicate when representative water from the surrounding formation is discharging from the pump. Field parameter measurements will be read from the instrument display and recorded at regular intervals on the purge log. Purging will be completed and sampling will commence when the indicator parameters have stabilized according to the guidelines established in the USEPA Science and Ecosystem Support Division Operating Procedure of Groundwater Sampling (SESDPROC-301-R3, 2013) below:

- pH measurements remain stable within 0.1 Standard Units for at least three consecutive measurements
- Specific conductance varies by no more than approximately 5% for at least three consecutive measurements
- DO is below 0.2 milligrams per liter
- Turbidity has either stabilized (within 10% for at least three consecutive measurements) or is below 10 nephelometric turbidity units

Readings will be taken roughly every 3 to 5 minutes, or at spacing determined by the flow rate to confirm complete turnover of the flow through cell volume. If stabilization of the indicator parameters (as defined above) has not been achieved after the removal of three well volumes, additional well volumes may be removed. If the parameters have not stabilized after the removal of five well volumes, a sample will be collected from the well.

Groundwater samples will be collected directly from the discharge tube of the pump into laboratory-provided sample containers that will be labeled prior to sample collection. Samples will be placed on ice in a sample cooler and shipped under chain of custody procedures to TestAmerica Laboratories in Savannah, Georgia where they will be analyzed for VOCs by USEPA Method 8260B and SVOCs by USEPA Method 8270. The results will be compared to the 2L Standards.

### 3.5.2 Additional Groundwater Investigation (Phase 2)

Additional groundwater investigation will be completed following the completion of the comprehensive groundwater sampling and soil investigation referenced above. The data collected during Phase 1 of the investigation will be used to guide placement of the vertical aquifer profile (VAP) borings that will be used to characterize COIs in groundwater downgradient from the sources. The anticipated areas where VAP sampling will be completed is shown on **Figure 3-1**, but may be adjusted based on data collected prior to completing these borings.

VAP borings will target both the saprolite and PWR HSUs. The points will be spaced approximately 50 to 100 feet apart based on the area being investigated and are anticipated to average 60 feet in depth, which corresponds to the top of bedrock based on the available site data. VAP samples will be collected, on average, every 10 feet vertically from the top of water saturation to total VAP boring depth. The exact number will depend on the actual depth to water and depth of bedrock encountered at each location. Each location will be drilled with sonic drilling methodologies to provide a continuous core sample at each location. The core samples will be logged for each interval before advancing to the next one. The field geologist will determine the location of the sample based on the characteristics of the soil profile and the sample intervals will be biased to zones where the lithology indicates a higher permeability (i.e., coarse-grained materials).

After the sample interval is selected, a temporary well screen will be placed at the bottom of the casing. The casing will then be retracted, exposing the target interval. A packer will be inflated above the screen to isolate the target sampling interval. Groundwater samples will be collected from the temporary well screen by using a peristaltic pump or bladder pump to purge the sample interval until free of fine-grained material. After purged, the flow rate will be reduced to allow sample collection in 40-milliliter volatile organic analysis vials. At each proposed sample interval, a minimum of three casing volumes of groundwater will be removed prior to sample collection. After the purging is completed, the final field parameters (pH, DO, ORP, and conductivity) will be recorded. TestAmerica Laboratories in Savannah, Georgia will analyze the groundwater samples using USEPA Method 8260. Additional analytes (e.g., SVOCs) may be included based on the outcome of the Phase 1 groundwater sampling results.

At the completion of each VAP location, borings will be abandoned. Abandonment will be completed by removing the VAP tooling and installing a 1-inch tremie pipe. Portland Type 1 cement will be added to the borehole as the downhole tooling is removed. The cement will be emplaced to ground surface. After

completion, the location will be staked and clearly labeled so the location can be surveyed at the completion of the drilling activities.

In addition to the VAP sampling, select borings will be advanced into the bedrock to further evaluate the extent of COIs in groundwater and assess the characteristics of the bedrock. The location of these borings will be based on the lateral distribution observed during the VAP sampling. It is anticipated that three locations will be selected for bedrock characterization.

The borings will initially be installed as open-hole bedrock wells to facilitate further testing upon installation. The surface casing will be constructed of 6-inch-dimeter, Schedule 80 polyvinyl chloride (PVC) and will be installed approximately 10 feet into bedrock. The bedrock will then be drilled using PQ-sized (85 millimeter inside diameter) wireline coring to allow the bedrock to be characterized. The borehole will extend approximately 50 feet below the base of the surface casing to provide an adequate vertical interval for characterization.

After the coring is completed, borehole geophysical logging will be completed at the three locations to evaluate the occurrence and characteristics of the fractures and groundwater flow in the bedrock. The logging suite will include calliper, acoustic televiewer, optical televiewer, fluid temperature, fluid conductivity, and heat pulse flow meter. The borehole geophysical results, as well as with the visual observations from the core samples will be evaluated to identify the fractures present within the borehole. These intervals will then be isolated with packers, and groundwater samples will be collected to evaluate the vertical distribution within the borehole. Sampling will be completed by purging three volumes of groundwater from the isolated interval. VOC samples will be collected at the completion of the sampling and will be shipped to TestAmerica Laboratories in Savannah, Georgia for analysis using USEPA Method 8260.

Upon receipt of the data, a 2-inch well will be constructed in the open borehole to isolate the interval where the highest COIs are detected. This will provide a monitoring point for follow-up sampling and provide a way to seal the borehole and avoid potential interconnection of fractures. If no COIs are detected, the location will either remain as an open hole bedrock well or be abandoned.

### 3.5.3 Monitoring Well Installation

At the completion of the groundwater investigation, additional monitoring wells may be installed to provide additional fixed monitoring locations that are better located to monitor the groundwater quality based on information developed during the VAP sampling. If additional wells are necessary, the locations and depth of completion of these wells will be determined based on the VAP results and the well would likely be installed in pairs, with the shallower well screened in the saprolite or PWR HSUs and the deeper well installed in the bedrock HSU.

The wells will be installed using conventional drilling methodologies, such as hollow-stem auger, air rotary, or sonic. The wells will be completed as 2-inch-diameter monitoring wells. Screen lengths will be customized base on the data, but are anticipated to be 5 to 10 feet in length. The well screens will be constructed of 304 stainless steel vee-wire with a 0.01 inch opening.

## 3.6 Surface-Water Investigation (Phase 1)

The site surface water within the unnamed stream will be characterized using two different methods that include grab and passive diffusion bag (PDB) sampling techniques. The two methods used in collocated areas provide an understanding of the extent of the mass discharge to the stream (PDBs) and the resulting surface-water quality along the flow path (grab). These co-located samples will be collected at approximately 100-foot intervals from the downstream extent of the unnamed stream on the site (where the stream enters a culvert), upstream to Electronics Drive. Two additional samples will be placed between Electronics Drive and the point where the unnamed stream enters the site at the western property boundary. These two most upstream samples will serve as background locations because they are upstream of the anticipated discharge points of groundwater that most likely contains COIs. Locations of surface-water sampling locations are shown on **Figure 3-1**. A summary of each method is included below.

The PDB portion of the surface-water investigation will include the deployment of nine PDBs in the base of the stream channel. The use of the PDB samplers will provide VOC concentrations at the groundwater/surface-water transition zone (*ECO Update/Ground Water Forum Issue Paper: Evaluating Ground-Water/Surface-Water Transition Zones in Ecological Risk Assessments*, dated July 2008), which is considered to be more representative of the water quality conditions as they enter surface water. The resulting data will provide an understanding of the groundwater discharge area and further refine the understanding of mass distribution across the site.

Installation of the samplers will be completed using a hand auger to auger approximately 2 feet below the base of the stream. Once the auger boring is completed, the PDB will be inserted to the base of the boring in accordance with the manufacturer's specification. The diffusion bags will be protected using a canister composed of 2-inch-diameter slotted Schedule 40 PVC. The canister will be tied off from the top of the canister to a nearby tree so it can be identified at the time of sampling. The PDBs will remain in place for a minimum of 14 days while they equilibrate with the groundwater entering the stream. After the PDBs have equilibrated, they will be removed and the water inside the sampler will be transferred to laboratory-supplied bottles for VOC analysis.

Grab samples will be collected to determine the surface-water quality and will provide data for evaluating the changes in VOC concentrations as groundwater discharges to surface water. Ten grab samples are proposed for this investigation. Nine grab samples will be collocated with the PDB samples and will be collected prior to removing the PDB from the stream bed. One additional sample will be collected approximately 1,300 feet east of the site where the stream daylights prior to entering into Marsh Creek. All samples will be collected from downstream to upstream to avoid any sediment disturbance. Grab samples will be collected using the fill method in accordance with the USEPA Standard Operating Procedure #EH-01 *Surface Water Collection* (USEPA 2003).

All PDB and grab samples will be shipped via FedEx in sealed ice-filled coolers under appropriated chain-of-custody procedures to TestAmerica Laboratories in Savannah, Georgia. The samples will be analyzed for VOCs using USEPA Method 8260B. As a quality assurance/quality control (QC) measure, duplicate samples will be collected at a frequency of one duplicate for every 10 samples collected.

## 3.7 Vapor Intrusion Investigation (Phase 1)

A step wise approach to evaluating the VI pathway is recommended in accordance with NCDENR DWM Vapor Intrusion Guidance (April 2014) and the Supplemental Guidelines for the Evaluation of Structural Vapor Intrusion Potential for Site Assessments and Remedial Actions Under the (NCDENR) Inactive Hazardous Sites Branch (IHSB Guidance 2014). Although groundwater is not fully delineated along the entirety of the eastern site boundary along Atlantic Avenue, historical groundwater sample data from samples collected near Atlantic Avenue indicate concentrations of TCE are present near the property boundary at concentrations exceeding 10 times the residential groundwater screening level (GWSL) of 1.04 µg/L. This GWSL was calculated by the DWM using the USEPA Vapor Intrusion Screening Level calculator at the lower of a $1x10^{-5}$ cancer risk level and a non-cancer hazard quotient (HQ) of 0.2. Based on the exceedances of the GWSL, additional sampling is recommended per the IHSB Guidance.

As a next step, soil gas sampling is recommended from the onsite side of Atlantic Avenue to evaluate the potential for VI from VOCs contained in site groundwater. While onsite concentrations of VOCs exceed the GWSL, downgradient samples from a single collocated pair of offsite groundwater monitoring wells historically show much lower concentrations of VOCs, approaching the limit of detection. Unfortunately, groundwater from this well set was sampled only one time; therefore, historical data has never been independently confirmed. In addition, it is unclear whether the location of the wells are ideally suited to intersect the center of mass of dissolved VOCs in offsite groundwater and, therefore, there remains uncertainty regarding the position of the downgradient extent of dissolved-phase VOCs. Should exceedances of the soil gas screening levels be noted, additional sampling may be warranted as a second phase of the VI investigation.

### 3.7.1 Sampling Methods

Exterior soil gas samples should be collected from locations where groundwater exceeded the GWSLs. Proposed sample locations are presented on **Figure 3-1**. Prior to the installation of sample points, each location will be cleared of utilities utilizing at least three lines of evidence. Sample locations will be adjusted as necessary to avoid any underground anomalies or utilities. Semi-permanent sampling points will be installed using a drill rig or direct-push rig to reach the target depth. After waiting 24 hours, the integrity of each sample port will be tested using a helium tracer gas test. After passing this QC step, the samples will be collected in 1-liter batch-certified SUMMA canisters. A sample of the soil vapor will be collected over a 10-minute interval at each location, and the sample will be analyzed for VOCs using USEPA Method TO-15. Sample collection will be terminated after the allotted sample period has elapsed or when the vacuum in each canister reaches 5 inches of mercury, whichever comes first. After review of the laboratory analytical data, sample points will be removed, or left in place if additional sampling is warranted. Detailed methods for the sample point installation, helium tracer leak test, and sample collection are included as **Appendices D** and **E**.

### 3.7.2 Data Evaluation

Initial soil gas samples will be evaluated by comparing sample results for each detected constituent to NCDENR DWM screening levels for residential soil gas at a $1x10^{-5}$ cancer risk level or a non-cancer HQ

of 0.2. No additional work will be proposed to evaluate the VI pathway, should no exceedances of the screening levels be noted.

# 4 REPORTING

If requested by counsel, data generated during this investigation will be reported in a comprehensive report that will include a summary of all data collected during the investigation, an updated CSM, and recommendations regarding next steps.

# 5 SCHEDULE

The following schedule has been included for the activities proposed in this Work Plan. The durations assume standard turnaround time for laboratory analytical data.

| Task | Duration | Predecessors |
|---|---|---|
| **Surface-Water Sampling** | 4 weeks | Notice to Proceed |
| **Groundwater Sampling (Phase 1)** | 3 weeks | Notice to Proceed |
| **VI Sampling** | 3 weeks | Notice to Proceed |
| **AGI Sampling** | 4 weeks | Notice to Proceed |
| **Phase 1 Soil (Main Building)** | 4 weeks | Building Demolition |
| **Phase 2 Soil (All Areas)** | 4 weeks | Phase 1 Soil and AGI Sampling |
| **Groundwater Investigation (Phase 2)** | 6 weeks | Groundwater Sampling, Surface Water Sampling and Phase 2 Soil |
| **Well Installation** | 3 weeks | Groundwater Investigation – Phase 2 |

# 6 REFERENCES

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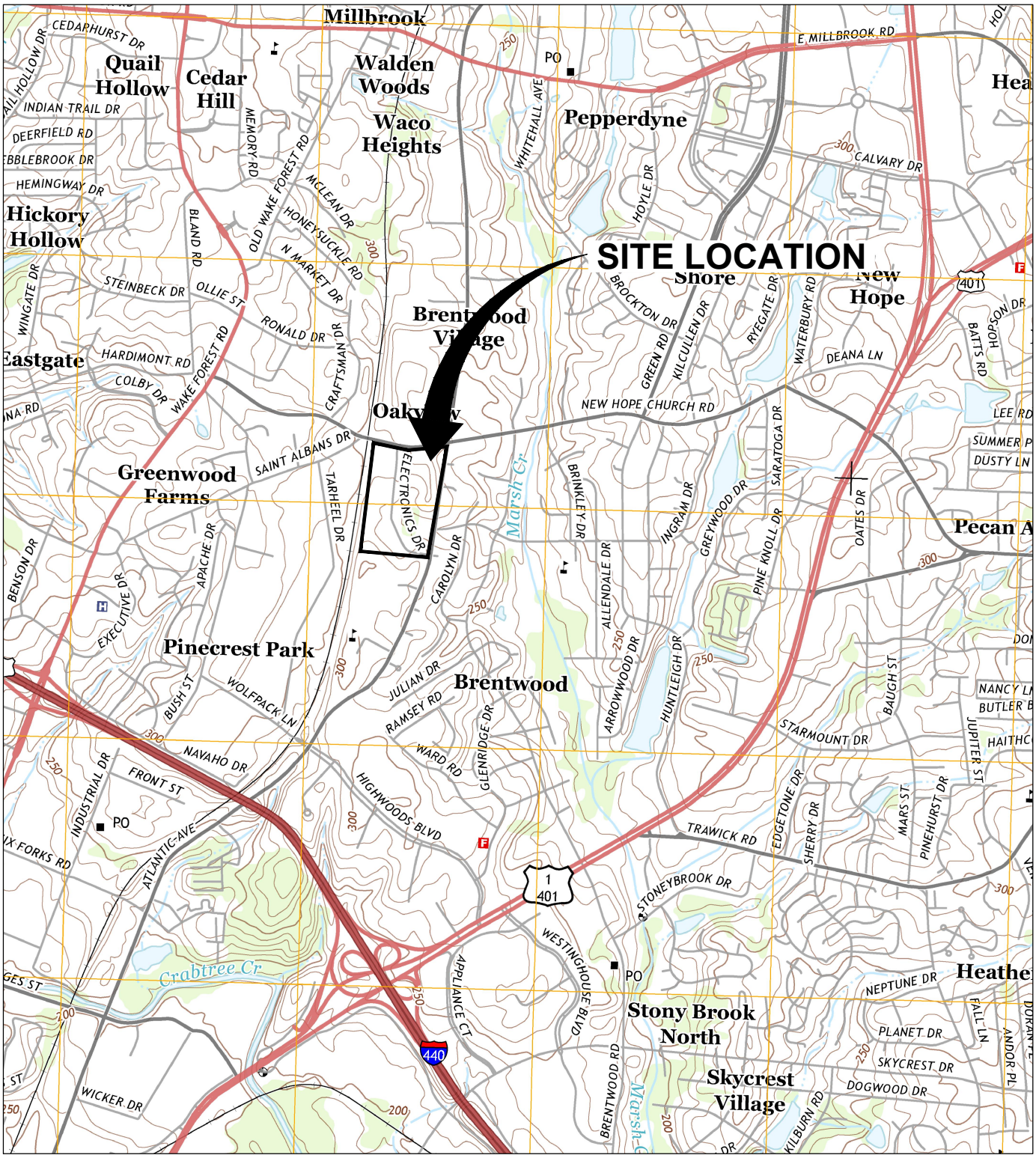
# TABLE

**Table 2-1**
**Well Construction Details**
**Investigation Work Plan**
**AVX Corporation Site**
**Raleigh, North Carolina**

| Well ID | Date of Installation | Top of Casing Elevation (ft amsl) | Stick-up (ft) | Ground Surface Elevation (ft amsl) | Screened Interval (ft btoc) | | Screened HSU* |
|---|---|---|---|---|---|---|---|
| | | | | | Top | Bottom | |
| MW-1A | 5/11/1989 | 284.89 | 2.04 | 282.85 | 21.99 | 26.99 | Saprolite |
| MW-1B | -- | 284.72 | -- | -- | 49.92 | 59.92 | -- |
| MW-2 | -- | 277.42 | -- | -- | 25.17 | 35.17 | -- |
| MW-3A | -- | 278.40 | -- | -- | 26.10 | 36.10 | Saprolite |
| MW-3B | 5/16/1989 | 277.49 | 1.56 | 275.93 | 46.49 | 51.49 | Saprolite |
| MW-3C | 4/16/1991 | 277.41 | 1.58 | 275.83 | 100.78 | 105.78 | PWR |
| MW-4A | 5/12/1989 | 279.73 | 2.18 | 277.55 | 22.13 | 27.13 | Saprolite |
| MW-4B | 5/16/1989 | 278.89 | 1.64 | 277.25 | 46.59 | 51.59 | Saprolite |
| MW-5A | 5/11/1989 | 271.23 | 1.91 | 269.32 | 21.93 | 26.93 | Saprolite |
| MW-5B | 5/17/1989 | 271.04 | 1.82 | 269.22 | 46.64 | 51.84 | PWR |
| MW-6A | 4/9/1991 | 272.25 | 1.53 | 270.72 | 19.53 | 24.53 | Saprolite |
| MW-6B | 5/17/1989 | 271.99 | 1.54 | 270.45 | 46.49 | 51.49 | Saprolite |
| MW-7B | 4/15/1991 | 273.68 | 1.50 | 272.18 | 46.50 | 51.50 | Saprolite |
| MW-8B | 4/16/1991 | 271.20 | 1.44 | 269.76 | 46.44 | 51.44 | Saprolite |
| MW-9B | 4/17/1991 | 262.77 | 1.24 | 261.53 | 30.24 | 35.24 | PWR |
| MW-10A | 4/18/1991 | 287.41 | 1.67 | 285.74 | 36.67 | 41.67 | Saprolite |
| MW-10B | 4/26/1991 | 287.30 | 1.58 | 285.72 | 57.08 | 62.08 | PWR |
| MW-11A | 4/18/1991 | 279.66 | 1.41 | 278.25 | 21.41 | 26.41 | Saprolite |
| MW-11B | 4/23/1991 | 279.81 | 1.43 | 278.38 | 46.43 | 51.43 | Saprolite |
| MW-13A | 8/28/2013 | 252.72 | -0.28 | 253.00 | 11.00 | 21.00 | PWR |
| MW-13B | 8/27/2013 | 252.98 | -0.22 | 253.20 | 35.00 | 45.00 | FBR -55' |
| MW-14A | 7/15/2015 | -- | 2.49 | -- | 19.00 | 29.00 | Saprolite |
| MW-14B | 7/15/2015 | -- | 2.48 | -- | 60.00 | 65.00 | FBR -55' |
| MW-15A | 7/15/2015 | -- | 0.00 | -- | 18.00 | 28.00 | Saprolite |
| MW-16A | 7/16/2015 | -- | 0.00 | -- | 11.00 | 21.00 | Saprolite |
| OBS-1 | 4/11/1991 | 277.89 | 1.41 | 276.48 | 26.11 | 36.11 | Saprolite |
| OBS-2 | 4/11/1991 | 278.08 | 1.43 | 276.65 | 26.43 | 36.43 | Saprolite |
| RW-1 | 4/12/1991 | 277.68 | 1.31 | 276.37 | 25.78 | 35.78 | -- |
| RW-2 | -- | 278.09 | -- | -- | 23.99 | 38.99 | -- |
| RW-3 | -- | 277.52 | -- | -- | 24.02 | 39.02 | -- |
| RW-4 | -- | 276.30 | -- | -- | 24.00 | 39.00 | -- |
| RW-5 | -- | 273.36 | -- | -- | 33.96 | 83.96 | -- |
| RW-6 | -- | 270.12 | -- | -- | 34.02 | 64.02 | -- |
| RW-7 | -- | 270.92 | -- | -- | 39.02 | 49.02 | -- |
| RW-8 | -- | 270.18 | -- | -- | 38.38 | 48.38 | -- |
| RW-9 | -- | 264.77 | -- | -- | 38.97 | 48.97 | -- |
| RW-10 | -- | 264.29 | -- | -- | 35.49 | 45.49 | -- |
| RW-11 | -- | 261.09 | -- | -- | 18.99 | 28.99 | -- |
| RW-12 | -- | 281.32 | -- | -- | 24.02 | 39.02 | -- |
| RW-12B | -- | 260.24 | -- | -- | 26.46 | 36.65 | -- |

**Notes:**
-- = data not available
amsl = above mean sea level
btoc = below top of casing
ft = feet
HSU = hydrostratigraphic unit
PWR = partially weathered rock

# FIGURES




REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD., RALEIGH EAST, NORTH CAROLINA, 2013

0 2000' 4000'

GRAPHIC SCALE

NORTH CAROLINA

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

## SITE LOCATION MAP

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1-1

CITY: SYRACUSE, NY DIV/GROUP: EBC-IM/DV DB/LD: R. BASSETT PIC: PM/TM: M. HANISH TR: LYR:(Opt)ON=*;OFF=*REF*
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**LEGEND:**

- GROUNDWATER MONITORING WELL
- GROUNDWATER OBSERVATION WELL
- GROUNDWATER RECOVERY WELL
- FORMER BUILDING
- APPROXIMATE PROPERTY LINE
- UNNAMED STREAM (ABOVE GROUND)
- UNNAMED STREAM (BELOW GROUND)
- INTERMITTENT DRAINAGE AND/OR TRIBUTAR TO UNNAMED STREAM

**NOTE:**

1. ALL LOCATIONS ARE APPROXIMATE.
2. WELL LOCATIONS ARE FROM FIGURE CREATED BY AMEC. SOIL BORING LOCATIONS ARE FROM FIGURE CREATED BY MID ATLANTIC ENGINEERING AND ENVIRONMENTAL SOLUTIONS.
3. AERIAL FROM USGS EARTH EXPLORER, DATED 2/1/13.

0 160' 320'

GRAPHIC SCALE

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

**SITE PLAN**

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1-2

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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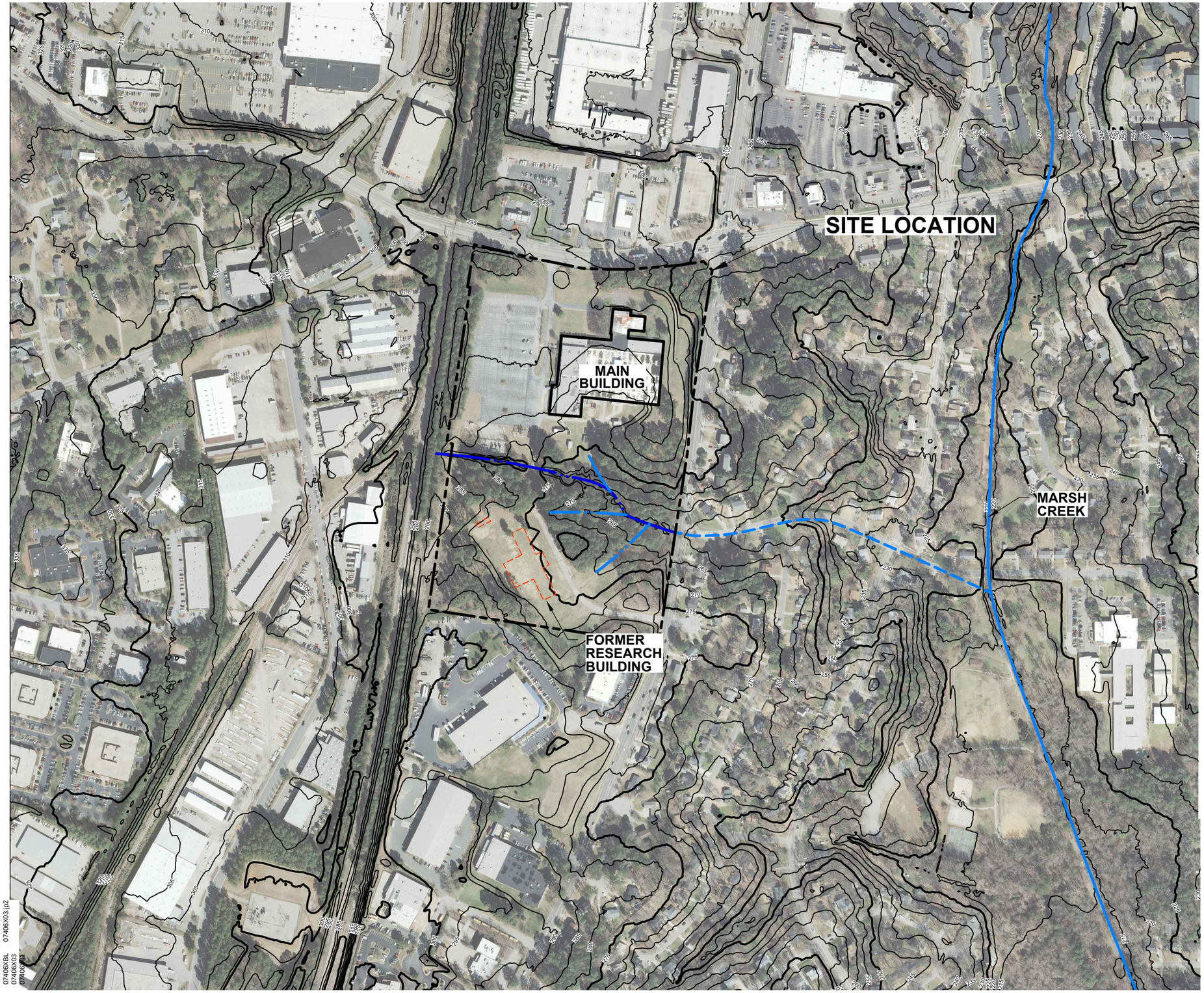


**LEGEND:**

- APPROXIMATE PROPERTY LINE
- UNNAMED STREAM (ABOVE GROUND)
- UNNAMED STREAM (BELOW GROUND)
- INTERMITTENT DRAINAGE AND/OR TRIBUTARY TO UNNAMED STREAM
- MARSH CREEK

**NOTE:**

1. ALL LOCATIONS ARE APPROXIMATE.
2. AERIAL FROM USGS EARTH EXPLORER, DATED 2/1/13.
3. TOPOGRAPHY OBTAINED FROM http://www.wakegov.com/gis/services/Pages/data.aspx DATED 2013.
4. SITE PLAN IS IN NAD 83, NORTH CAROLINA STATE PLANE – US FEET.

0 400' 800'

GRAPHIC SCALE

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

**LOCAL TOPOGRAPHY AND HYDROLOGY**

ARCADIS Design & Consultancy for natural and built assets

FIGURE 2-1

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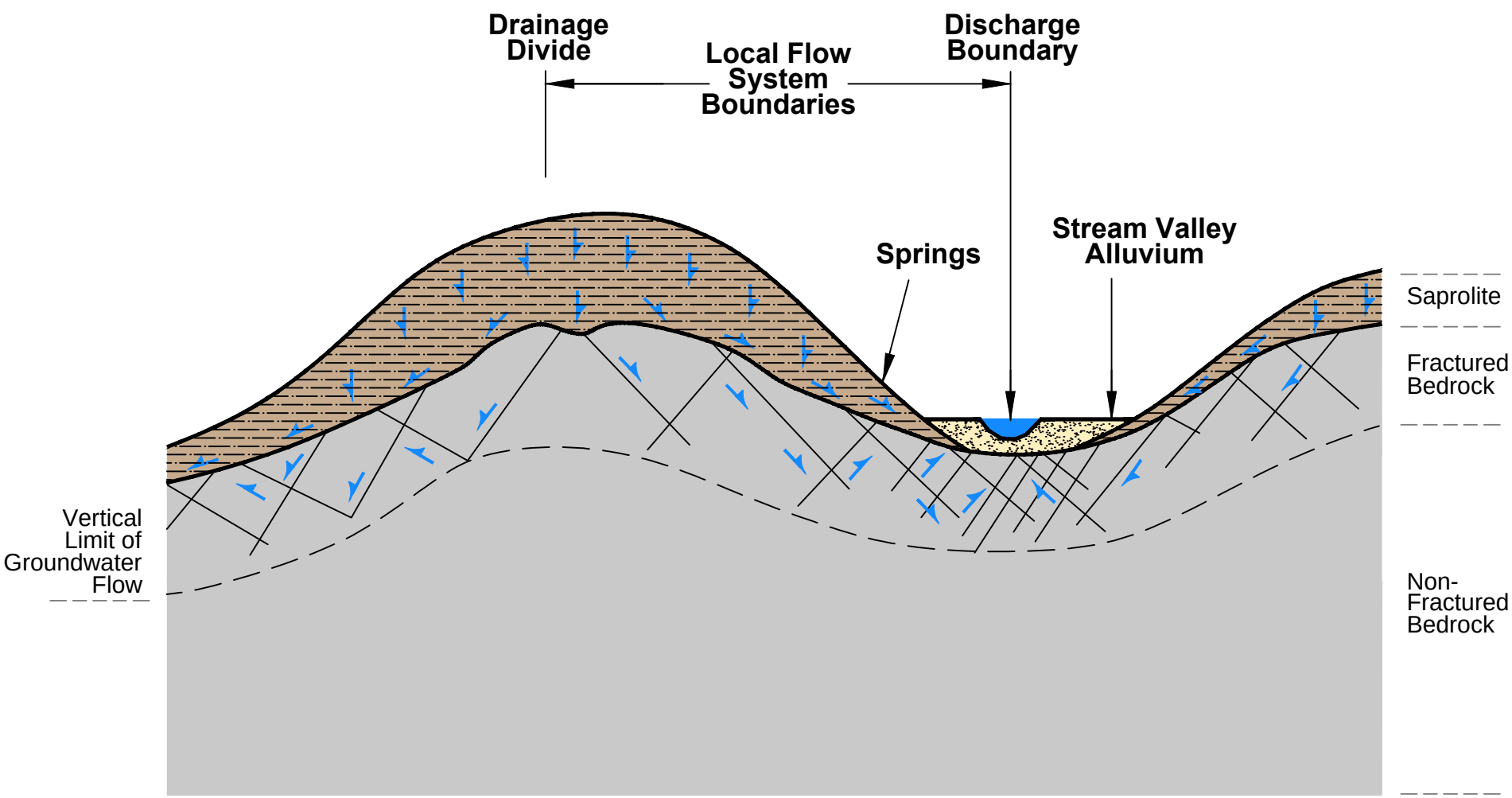
07406X03




**LEGEND**

- Recent Alluvium
- Saprolite
- Fractured Bedrock
- Groundwater Flow Direction

(Adapted from LeGrand, 2004)

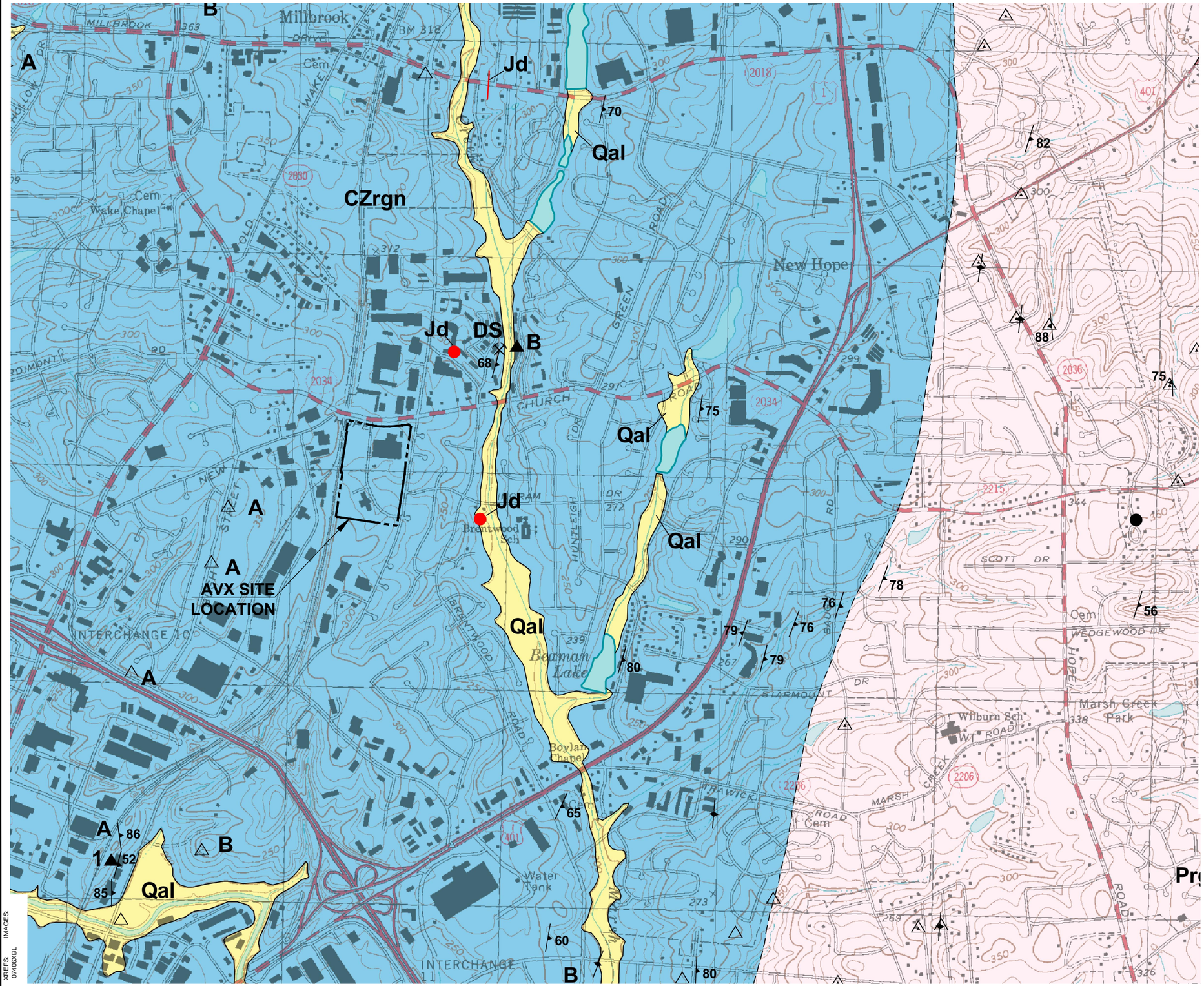
**NOT TO SCALE**

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

**CONCEPTUAL GROUNDWATER FLOW IN THE PIEDMONT**

ARCADIS Design & Consultancy for natural and built assets

FIGURE
**2-2**




## LEGEND:

APPROXIMATE PROPERTY LINE

### SEDIMENTARY/SURFICIAL UNITS

Qal – QUANTERNARY ALLUVIUM: UNCONSOLIDATED, POORLY SORTED AND POORLY STRATIFIED TAN TO LIGHT GRAY STREAM DEPOSITS OF GRAVEL, SAND, SILT AND CLAY. SIMILAR TO TERRACES ALONG STREAMS

### IGNEOUS UNITS

Prg – ROLESVILLE GRANITE: GRAY–WHITE TO PINK–WHITE, MEDIUM–GRAINED, LOCALLY WEAKLY PORPHYRITIC, MODERATE– TO WELL–FOLIATED, LEUCOCRATIC (CI<15) BIOTITE GRANITE AND PINK–WHITE, MEDIUM– TO COARSE–GRAINED, UNFOLIATED TO WEAKLY FOLIATED GRANITE. LOCALLY PEGMATITIC GRANITE

### RALEIGH TERRANE

CZrgn – RALEIGH GNEISS: PINKISH–GRAY TO TAN–GRAY, MEDIUM–GRAINED, WEAKLY TO MODERATELY FOLIATED BIOTITE–BEARING GRANITIC ORTHOGNEISS; BLACK–GRAY TO TAN–GRAY, MEDIUM–GRAINED, MODERATELY FOLIATED, VARIABLY LAYERED BIOTITE +/– HORNBLENDE–BEARING QUARTZ=PLAGIOCLASE GNEISS AND SCHIST; AND LESSER GRAY–BLACK, FINE–GRAINED AMPHILBOLITE AND GOLD–BROWN, MEDIUM–GRAINED BIOTITE SCHIST.

**NOTE:**

1. ALL LOCATIONS ARE APPROXIMATE.
2. AERIAL FROM USGS EARTH EXPLORER, DATED 2/1/13.
3. TOPOGRAPHY OBTAINED FROM http://www.wakegov.com/gis/services/Pages/data.aspx DATED 2013.
4. SITE PLAN IS IN NAD 83, NORTH CAROLINA STATE PLANE – US FEET.

0 1500' 3000'

GRAPHIC SCALE

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

## GEOLOGIC MAP OF SITE LOCATION AND SURROUNDING AREA

ARCADIS Design & Consultancy for natural and built assets

FIGURE 2-3

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(On)ON=*;OFF=*REF* PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/1/2016 4:27 PM BY: SCHILLING, ADAM
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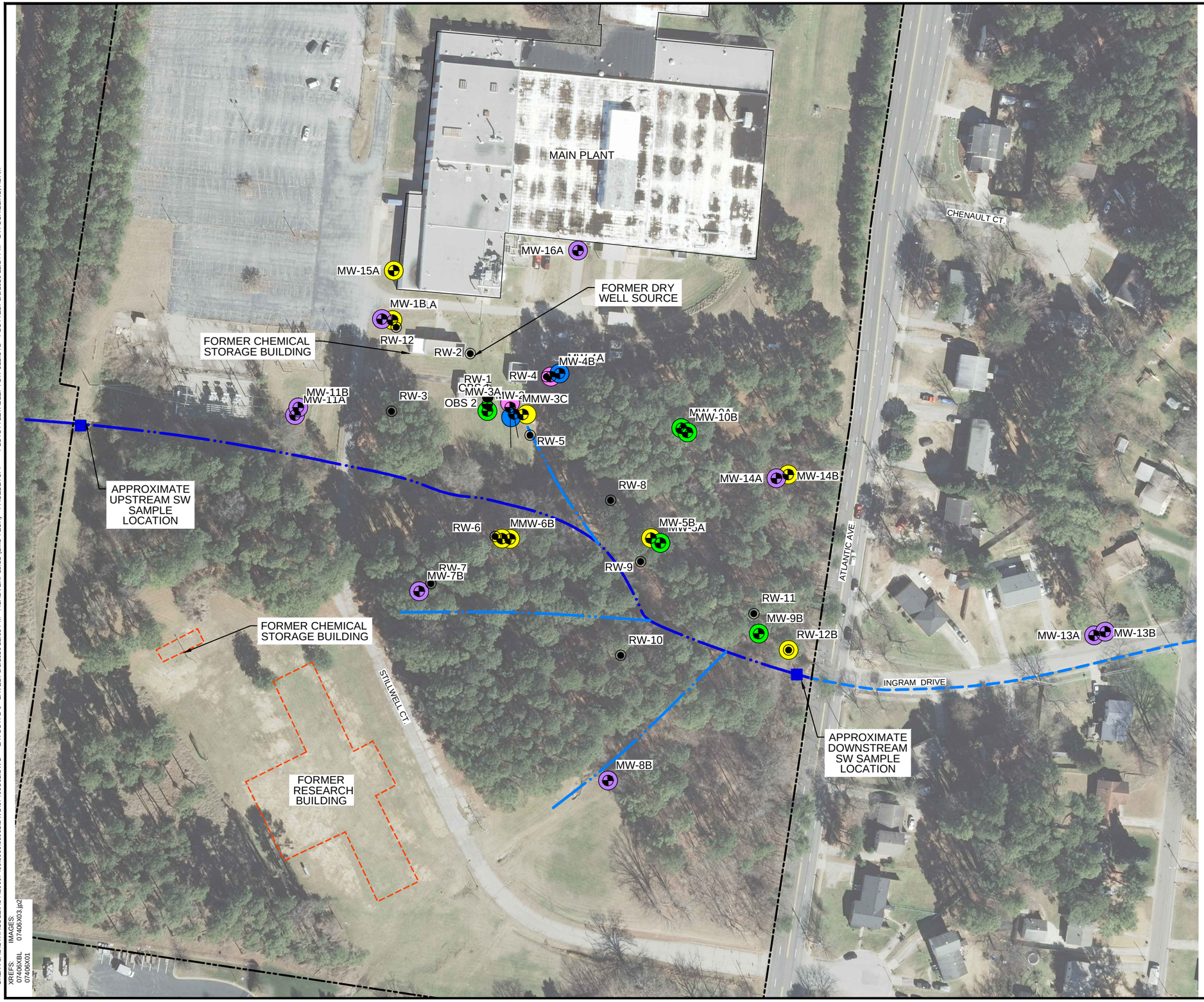


**LEGEND:**

- GROUNDWATER MONITORING WELL
- GROUNDWATER OBSERVATION WELL
- GROUNDWATER RECOVERY WELL
- FORMER BUILDING
- APPROXIMATE PROPERTY LINE
- UNNAMED STREAM (ABOVE GROUND)
- UNNAMED STREAM (BELOW GROUND)
- INTERMITTENT DRAINAGE AND/OR TRIBUTAI TO UNNAMED STREAM

**TCE CONCENTRATIONS (µg/L)**

- >10,000
- >1,000 AND </=10,000
- >100 AND </=1,000
- >10 AND </=100
- >3 AND </=10
- </= 3

**NOTE:**

1. ALL LOCATIONS ARE APPROXIMATE.
2. WELL LOCATIONS ARE FROM FIGURE CREATED BY AMEC. SOIL BORING LOCATIONS ARE FROM FIGURE CREATED BY MID ATLANTIC ENGINEERING AND ENVIRONMENTAL SOLUTIONS.
3. AERIAL FROM USGS EARTH EXPLORER, DATED 2/1/13.

0 120' 240'

GRAPHIC SCALE

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

**TRICHLOROETHENE (TCE) CONCENTRATION IN GROUNDWATER**

ARCADIS Design & Consultancy for natural and built assets

FIGURE
**2-4**

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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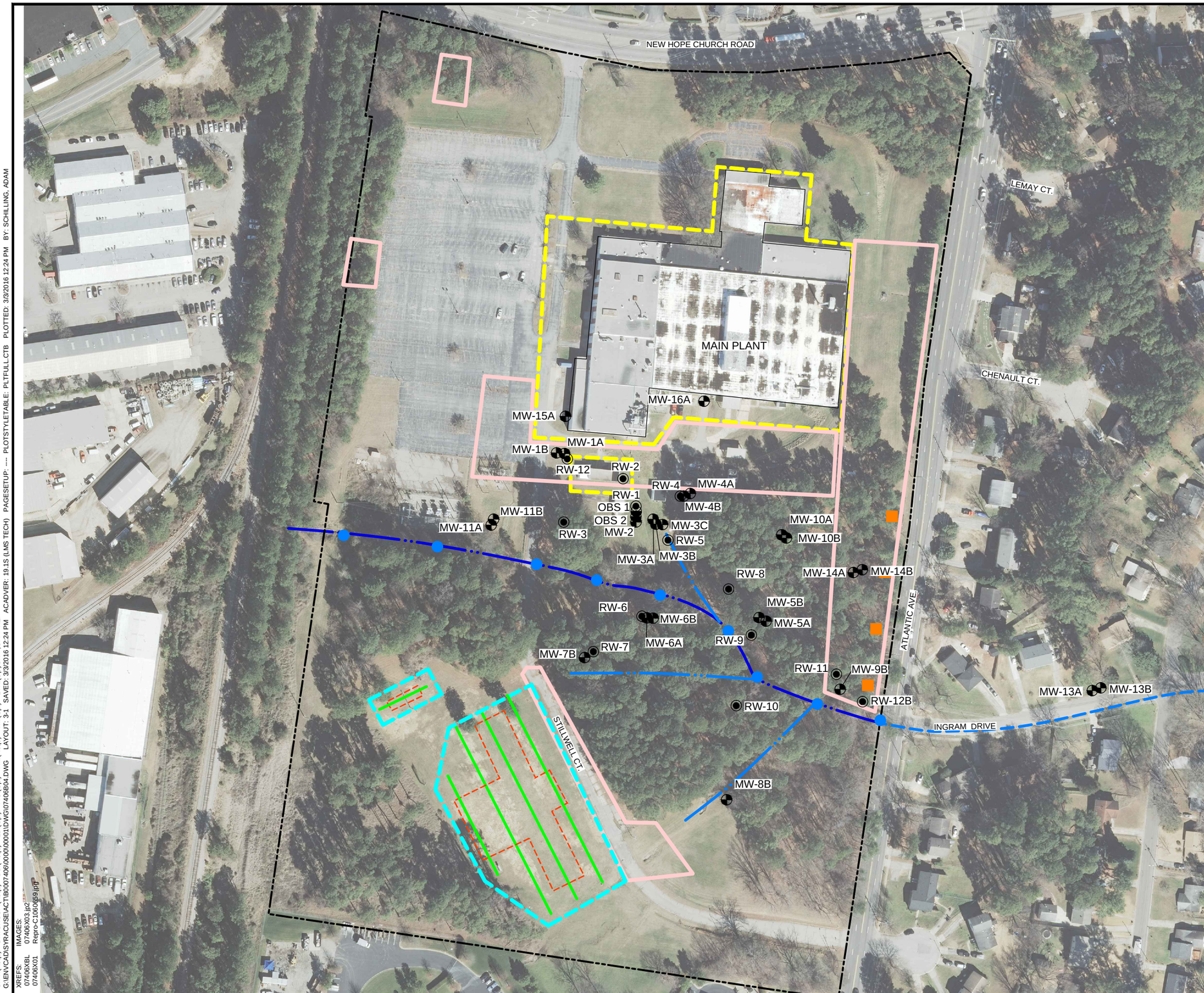


**LEGEND:**

- GROUNDWATER MONITORING WELL
- GROUNDWATER OBSERVATION WELL
- GROUNDWATER RECOVERY WELL
- FORMER BUILDING
- APPROXIMATE PROPERTY LINE
- UNNAMED STREAM (ABOVE GROUND)
- UNNAMED STREAM (BELOW GROUND)
- INTERMITTENT DRAINAGE AND/OR TRIBUTAR TO UNNAMED STREAM
- PHASE 1 SOIL INVESTIGATION AREA*
- AGI SAMPLER TRANSECT (PHASE 1)
- PHASE 2 SOIL INVESTIGATION AREA*
- GROUNDWATER INVESTIGATION AREA*
- SOIL VAPOR SAMPLING LOCATION
- SURFACE WATER SAMPLING LOCATION

**NOTE:**

1. ALL LOCATIONS ARE APPROXIMATE.
2. WELL LOCATIONS ARE FROM FIGURE CREATED BY AMEC. SOIL BORING LOCATIONS ARE FROM FIGURE CREATED BY MID ATLANTIC ENGINEERING AND ENVIRONMENTAL SOLUTIONS.
3. AERIAL FROM USGS EARTH EXPLORER, DATED 2/1/13.
4. * – AREAS REPRESENT EXPECTED AREA OF INVESTIGATION. THE AREA OF SOIL INVESTIGATION MAY BE MODIFIED BASED ON INITIAL SCREENING DATA. THE AREA OF ADDITIONAL GROUNDWATER INVESTIGATION WILL BE BASED ON INTERPRETATION OF DATA COLLECTED DURING PRIOR PHASE(S) OF INVESTIGATION FOR BOTH SOIL AND GROUNDWATER.

0 160' 320'

GRAPHIC SCALE

AVX CORPORATION
CORNING/AVX FACILITY
RALEIGH, NORTH CAROLINA

**SITE INVESTIGATION PLAN**

ARCADIS Design & Consultancy for natural and built assets

FIGURE
**3-1**

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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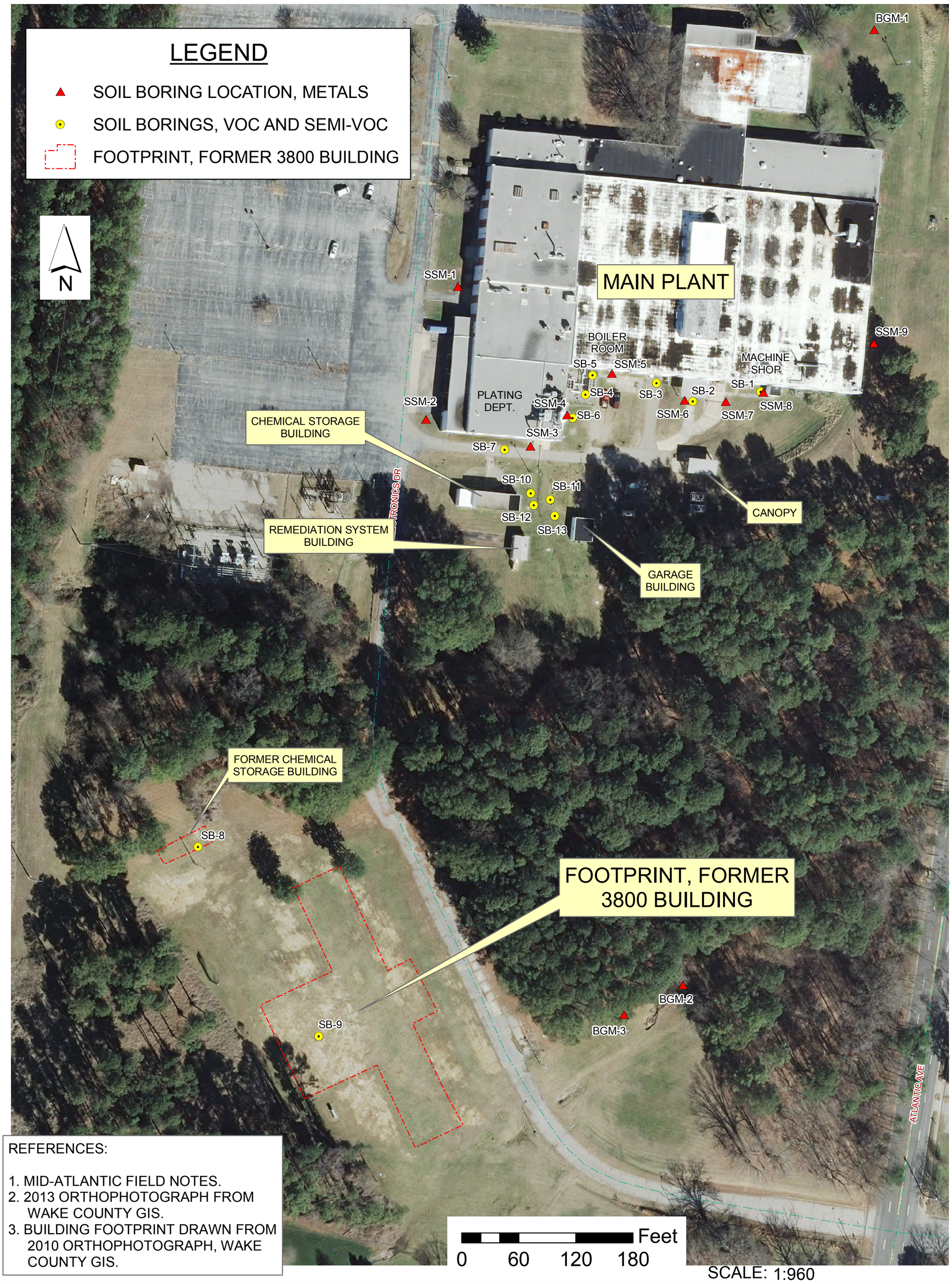
XREFS: 07406XBL 07406X01
IMAGES: 07406X03.jpg Repro-C1060659.jpg

# APPENDIX A

## Soil Sample Results – Mid-Atlantic 2015




REFERENCES:

1. MID-ATLANTIC FIELD NOTES.
2. 2013 ORTHOPHOTOGRAPH FROM WAKE COUNTY GIS.
3. BUILDING FOOTPRINT DRAWN FROM 2010 ORTHOPHOTOGRAPH, WAKE COUNTY GIS.

SCALE: 1:960

Mid Atlantic
Engineering & Environmental Solutions

SOIL BORING LOCATIONS
3900 ELECTRONICS DRIVE
RALEIGH, NORTH CAROLINA

| | |
|---|---|
| DRAWN BY: EBA | DATE: AUGUST 2015 |
| DRAFT CHECK: | JOB NO: 000R2678.00 |
| ENG. CHECK: | GIS NO: 01G-R2678.00-5 |
| APPROVAL: | DWG NO: B-1 |

TABLE B-2: SUMMARY OF SOIL SAMPLE LABORATORY RESULTS (VOLATILE ORGANIC COMPOUNDS), MG/KG
FORMER CORNING GLASS WORKS / AVX, INC.
3900 ELECTRONICS DRIVE, RALEIGH, NORTH CAROLINA
MID-ATLANTIC PROJECT NO. 000R2678.00

| | | Volatile Organic Compounds (EPA 8260B) | | | | | | Semi-VOCs EPA 8270C) |
|---|---|---|---|---|---|---|---|---|
| **Contaminant of Concern →** | | **Acetone** | **Carbon tetrachloride** | **Methylene chloride** | **Trichloroethene** | **Tetrachloroethene** | **Total Xylenes** | **Semi-volatile Organic Compounds (if detected), EPA Method 8270C** |
| **Sample ID** | **Date Collected** | | | | | | | |
| **Residential Health-Based Soil Remediation Goal (mg/kg)**, March 2015 IHSB Table | | 12000 | 65 | 57 | 82 | 16 | 120 | NA |
| **Protection of Groundwater Soil Remediation Goal (mg/kg),** March 2015 IHSB Table | | 24 | 0.0021 | 0.023 | 0.018 | 0.005 | 5.8 | NA |
| SB-1 (6-8') | 7/14/2015 | -- | -- | -- | -- | -- | -- | NT |
| SB-2 (8-10') | 7/16/2015 | -- | -- | -- | -- | -- | -- | NT |
| SB-3 (2-3') | 7/16/2015 | -- | -- | -- | -- | -- | -- | -- NC -- |
| SB-4 (8-10) | 7/15/2015 | -- | -- | -- | -- | -- | -- | -- NC -- |
| SB-5 (1-3') | 7/15/2015 | 0.11 | -- | -- | -- | -- | -- | -- NC -- |
| SB-6 (4-5') | 7/14/2015 | 0.10 | -- | -- | -- | -- | -- | NT |
| SB-7 (3-4') | 7/17/2015 | -- | -- | -- | -- | -- | -- | -- NC -- |
| SB-8 (1-3') | 7/15/2015 | -- | -- | -- | -- | -- | -- | -- NC -- |
| SB-9 (1-3') | 7/15/2015 | -- | -- | -- | -- | -- | -- | NT |
| SB-10 (6-8') | 7/17/2015 | 0.13 | -- | -- | -- | -- | -- | NT |
| SB-11 (6-8') | 7/17/2015 | 0.23 | -- | -- | -- | **0.0078** | 0.0019 J | NT |
| SB-12 (14-15') | 7/17/2015 | -- | -- | -- | -- | -- | 0.0024 J | NT |
| SB-13 (8-10') | 7/17/2013 | -- | -- | -- | -- | 0.0027 J | -- | NT |

Notes:

**Bold** = Concentration in Bold exceeds most stringent Soil Remediation Goal (typically Protection of Groundwater)

**--** = Analyte not detected above the Method Detection Limit (MDL) for undiluted samples, or sample was diluted but MDL is less than most stringent SRG.

NA = Not Applicable

-- NC -- = No compounds detected

J = Analyte detected but below the practical quantitation limit; therefore, the result is an estimated concentration.

IHSB = Inactive Hazardous Sites Branch

TABLE B-3: SUMMARY OF SOIL SAMPLE LABORATORY RESULTS (METALS), MG/KG
FORMER CORNING GLASS WORKS / AVX, INC.
3900 ELECTRONICS DRIVE, RALEIGH, NORTH CAROLINA
MID-ATLANTIC PROJECT NO. 000R2678.00

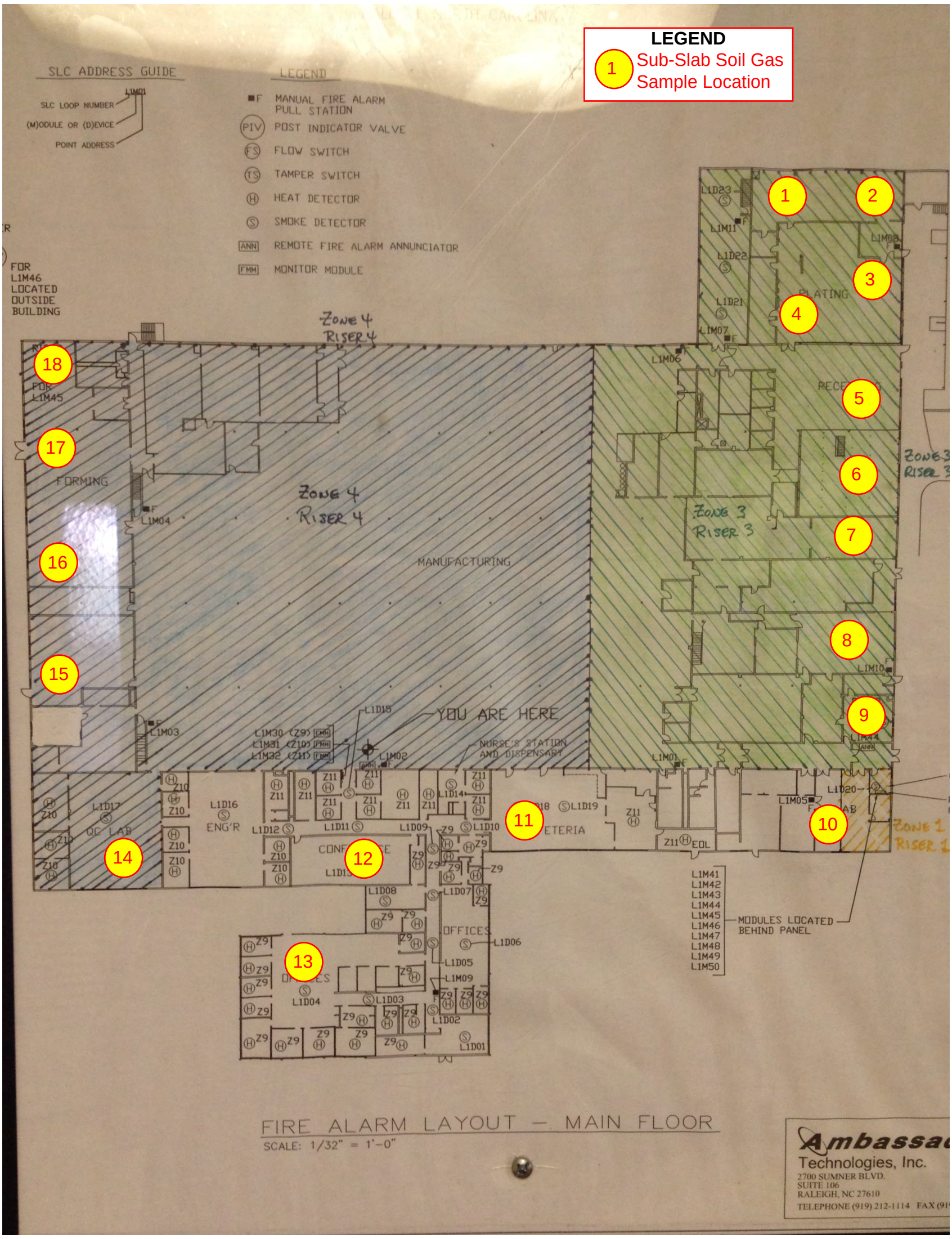
| Sample | Sampling Date | Barium | Lead | Nickel | Silver | Tin | Zinc |
|---|---|---|---|---|---|---|---|
| **Health-Based Soil Remediation Goal (mg/kg)**, March 2015 IHSB Table | | 3,000 | 400 | 300 (Salts) | 78 | 9,400 | 4,600 |
| **Protection of Groundwater Soil Remediation Goal (mg/kg),** March 2015 IHSB Table | | 580 | 270 | 130 (Salts) | 3.4 | 10,000 | 1,200 |
| BGM-1 (0-1') | 7/21/2015 | 30 | 16 | 3.4 | -- | -- | 28 |
| BGM-2 (0-1') | 7/21/2015 | 42 | 12 | 9.5 | -- | -- | 39 |
| BGM-3 (0-1') | 7/21/2015 | 79 | 29 | 14 | -- | -- | 42 |
| SSM-1 (0-1') | 7/21/2015 | 130 | 180 | 9 | **9.9** | -- | 170 |
| SSM-2 (0-1') | 7/21/2015 | 290 | 190 | 12 | **9.6** | -- | 97 |
| SSM-3 (0-1') | 7/21/2015 | 120 | 63 | 11 | **4.3** | -- | 81 |
| SSM-4 (0-1') | 7/21/2015 | 27 | 8.7 | 3.7 | -- | -- | 26 |
| SSM-5 (0-1') | 7/21/2015 | 39 | 20 | 11 | -- | -- | 56 |
| SSM-6 (0-1') | 7/21/2015 | **4300*** | 100 | 14 | **11** | -- | 74 |
| SSM-7 (0-1') | 7/21/2015 | 250 | 7.1 | 19 | -- | -- | 83 |
| SSM-8 (0-1') | 7/21/2015 | 43 | 30 | 8.6 | 0.65 | -- | 38 |
| SSM-9 (0-1') | 7/21/2015 | 38 | 130 | 6.1 | 2.4 | -- | 80 |
| Range of Detected Values | All dates | 27 to 4300 | 7.1 to 190 | 3.4 to 19 | 0.65 to 9.9 | -- | 28 to 170 |
| Mean of Detected Values | All dates | 98.9 | 65.5 | 10.1 | 6.3 | -- | 67.8 |
| Median of Detected Values | All dates | 43 | 29.5 | 10.25 | 6.95 | -- | 65 |

All concentrations in mg/Kg (parts per million)

**9.6** = Concentrations in bold (mg/Kg) exceed the lower of the Protection of Groundwater (PG) Soil Remediation Goal.
**4000** = Concentrations that are bold within a shaded cell exceed the Health-Based Soil Remediation Goal
* = Denotes a dilution factor of 10x
-- = Below Method Detection Limit for undiluted samples.
BGM = Background Metals (prefix for samples collected from "background" locations)
SSM = Surficial Soil Metals (prefix for metals samples)
RG = Remedial Goal
IHSB = Inactive Hazardous Sites Branch

# APPENDIX B

## Sub-Slab Vapor Results – Mid-Atlantic 2015




REFERENCES: 1. FIRE MAP PHOTOGRAPHED BY MID-ATLANTIC. 2. MID-ATLANTIC FIELD NOTES.

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MAIN FLOOR SUB-SLAB SOIL GAS SAMPLE LOCATIONS
FORMER CORNING GLASS WORKS / AVX, INC.
3900 ELECTRONICS DRIVE
RALEIGH, NORTH CAROLINA

| | |
|---|---|
| DRAWN BY: | DATE: AUGUST 2015 |
| DRAFT CHECK: | JOB NO: 000R2678.00 |
| ENG. CHECK: DHN | GIS NO: 03G-R2678.00-D1 |
| APPROVAL: DHN | DWG NO: D-1 |

REFERENCES: 1. FIRE MAP PHOTOGRAPHED BY MID-ATLANTIC. 2. MID-ATLANTIC FIELD NOTES.

Mid Atlantic
Engineering & Environmental Solutions

BASEMENT SUB-SLAB SOIL GAS SAMPLE LOCATIONS
FORMER CORNING GLASS WORKS / AVX, INC.
3900 ELECTRONICS DRIVE
RALEIGH, NORTH CAROLINA

| | | | |
|---|---|---|---|
| DRAWN BY: | KG | DATE: | AUGUST 2015 |
| DRAFT CHECK: | KG | JOB NO: | 000R2678.00 |
| ENG. CHECK: | DHN | GIS NO: | 03G-R2678.00-D2 |
| APPROVAL: | DHN | DWG NO: | D-2 |

**TABLE D-1 (Page 1 of 5)**
**SUMMARY OF SUB-SLAB SOIL GAS SAMPLING TEST RESULTS**
**FORMER CORNING GLASS WORKS / AVX, INC.**
**3900 ELECTRONICS DRIVE**
**RALEIGH, NORTH CAROLINA**
**MID-ATLANTIC JOB NO. 000R2678.00**

| Parameter | Residential Vapor Intrusion Screening Levels | Non-Residential Vapor Intrusion Screening Levels | SAMPLING LOCATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Residential Soil-Gas ug/m3 | Non-Residential Soil-Gas ug/m3 | VP-1 | VP-10 | VP-11 | VP-12 | VP-13 | VP-14 | VP-15 | VP-16 | VP-17 | VP-18 |
| Sampling Date and Time | | | 7/15/2015 11:35 AM | 7/14/2015 4:09 PM | 7/14/2015 2:31 PM | 7/14/2015 3:08 PM | 7/14/2015 3:38 PM | 7/15/2015 12:58 PM | 7/15/2015 12:42 PM | 7/15/2015 12:27 PM | 7/15/2015 12:12 PM | 7/15/2015 12:00 PM |
| ***EPA METHOD TO-15*** | | | | | | | | | | | | |
| Acetone | 216000 | 2720000 | 1100 | 650 | 490 , | 780 | 170 | 300 | 89 | 65 | 130 | 94 |
| Benzene | 120 | 1570 | ND (3.3) | 0.85 | 1.2 | 0.81 | 0.54 J | ND (0.41) | 0.43 J | 0.88 | 0.75 J | ND (0.41) |
| Benzyl Chloride | 6.95 | 87.6 | ND (2.0) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) |
| Bromodichloromethane | 25.30 | 331 | ND (2.9) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) |
| Bromoform | ~ | ~ | ND (4.0) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) |
| Bromomethane | 34.8 | 438 | ND (5.3) | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) | 3.1 |
| 1,3-Butadiene | 13.9 | 175 | ND (2.3) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) |
| 2-Butanone (MEK) | 34800 | 438000 | 37 J | 49 | 41 | 40 | 17 J | 17 J | 13 J | 11 J | 20 J | 19 J |
| Carbon Disulfide | 4870 | 61300 | ND (2.1) | 1.7 J | 2.0 J | 1.6 J | 2.6 J | 0.81 J | 2.9 J | 0.87 J | 1.6 J | 0.81 J |
| Carbon Tetrachloride | 156 | 2040 | ND (3.0) | ND (0.38) | ND (0.38) | ND (0.38) | 0.69 J | ND (0.38) | 0.41 J | 0.50 J | ND (0.38) | 0.41 J |
| Chlorobenzene | 348 | 4380 | ND (3.2) | 0.60 J | ND (0.40) | ND (0.40) | 0.51 J | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) |
| Chloroethane | 69500 | 876000 | ND (2.0) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | 2.0 |
| Chloroform | 40.7 | 533 | 2.9 J | 1.1 J | 12 | ND (0.29) | ND (0.29) | 2.3 | ND (0.29) | ND (0.29) | 0.44 J | 0.34 J |
| Chloromethane | 626 | 7880 | ND (1.8) | 0.63 J | ND (0.23) | 1.0 | 0.70 J | 0.50 J | 0.58 J | 0.77 J | 0.99 J | 9.1 |
| Cyclohexane | 41700 | 526000 | ND (4.0) | ND (0.49) | 2.5 | ND (0.49) | 5.0 | 2.5 | 3.5 | 3.4 | 4.9 | 4.2 |
| Dibromochloromethane | 34.70 | 454 | ND (4.5) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) |
| 1,2-Dibromoethane (EDB) | 1.56 | 20.4 | *ND (3.4)* | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) |
| 1,2-Dichlorobenzene | 1390 | 17500 | ND (3.2) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) |
| 1,3-Dichlorobenzene | ~ | ~ | 38 | 49 | 100 | 91 | 18 | 82 | 57 | 90 | 74 | 21 |
| p-Dichlorobenzene; 1,4-Dichlorobenzene | 85.10 | 1110 | ND (3.0) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) |
| Dichlorodifluoromethane (Freon 12) | 695 | 8760 | ND (4.3) | 5.5 | 6.1 | 6.2 | 6.8 | 6.8 | 17 | 12 | 9.8 | 4.7 |
| 1,1-Dichloroethane | 585 | 7670 | ND (2.3) | ND (0.29) | ND (0.29) | ND (0.29) | ND (0.29) | ND (0.29) | ND (0.29) | ND (0.29) | ND (0.29) | ND (0.29) |
| 1,2-Dichloroethane | 36 | 472 | ND (2.3) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) |
| 1,1-Dichloroethylene | 1390 | 17500 | ND (1.9) | ND (0.24) | ND (0.24) | ND (0.24) | ND (0.24) | ND (0.24) | ND (0.24) | ND (0.24) | ND (0.24) | ND (0.24) |
| cis-1,2-Dichloroethylene | ~ | ~ | ND (3.0) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) |
| trans-1,2-Dichloroethylene | | 5260 | ND (2.1) | ND (0.26) | ND (0.26) | ND (0.26) | ND (0.26) | ND (0.26) | ND (0.26) | ND (0.26) | ND (0.26) | ND (0.26) |
| 1,2-Dichloropropane | 27.8 | 350 | ND (3.2) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) |
| cis-1,3-Dichloropropene | ~ | ~ | ND (2.4) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) |
| trans-1,3-Dichloropropene | ~ | ~ | ND (2.4) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114) | ~ | ~ | ND (3.3) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) |
| 1,4-Dioxane | ~ | ~ | ND (46) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) |
| Ethanol | ~ | ~ | 1500 | 1100 | 410 , | 410 | 190 | 230 | 270 | 230 , | 340 | 360 |
| Ethyl Acetate | 487 | ~ | ND (5.4) | ND (0.67) | 5.7 | 5.3 | ND (0.67) | 6.0 | 26 | 26 | 44 | 16 |
| Ethylbenzene | 374 | 4910 | *1600* | 4.9 | 7.3 | 6.7 | 2.2 | 3.5 | 2.1 | 19 | 2.0 | 4.6 |
| 4-Ethyltoluene | ~ | ~ | 97 | 3.4 | 3.9 | 3.6 | 1.5 | 2.6 | 2.9 | 5.3 | 1.9 | 0.91 J |
| Heptane | ~ | ~ | ND (2.7) | 1.5 | 1.5 | 1.7 | ND (0.33) | 0.53 J | ND (0.33) | ND (0.33) | 1.1 | ND (0.33) |
| Hexachlorobutadiene | ~ | ~ | ND (8.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) |
| Hexane | 4870 | 61300 | ND (12) | 6.1 J | 9.2 J | 5.7 J | 7.4 J | 2.8 J | 3.2 J | 15 J | 18 J | 1.8 J |
| 2-Hexanone (MBK) | 209 | 2630 | 3.3 J | 7.7 | 6.8 | 4.0 | 2.9 | ND (0.26) | 3.0 | 3.2 | 5.6 | ND (0.26) |
| Isopropanol | ~ | ~ | 1000 | 4000 | 7500 | 13000 | 1900 | 880 | 240 | 310 | 140 | 110 |
| Methyl tert-Butyl Ether (MTBE) | 3600 | 47200 | ND (2.2) | 12 | 7.9 | 9.4 | ND (0.28) | ND (0.28) | 1.8 | 2.9 | 1.1 | 1.2 |
| Methylene Chloride | 4170 | 52600 | ND (8.4) | 1.8 J | 2.8 J | 1.9 J | 1.9 J | 1.5 J | 1.5 J | 1.3 J | ND (1.1) | ND (1.1) |
| 4-Methyl-2-pentanone (MIBK) | 20900 | 263000 | 71 | 22 | 17 | 15 | 3.7 | 6.2 | 5.6 | 6.7 | 5.3 | 3.3 |
| Naphthalene | 20.9 | 263 | *25* | 1.9 | 1.3 | 1.7 | 1.3 J | 2.5 | 1.8 | 1.8 | 2.0 | 1.9 |
| Propene | 20900 | 263000 | 13 J | 32 | 3.4 J | 3.8 J | 6.7 J | 3.6 J | 3.8 J | 11 J | 6.5 J | 5.7 J |
| Styrene (Ethenylbenzene) | 6950 | 87600 | ND (1.7) | 1.2 | 1.6 | 1.3 | 0.66 J | 1.7 | 1.3 | 1.4 | 1.3 | 0.98 J |
| 1,1,2,2-Tetrachloroethane | 16.1 | 211 | ND (3.3) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) |
| Tetrachloroethylene;Perchloroethylene | 278 | 3500 | 25 | 74 | 11 | 2.2 | *350* | 20 | 19 | 2.0 | 1.6 J | 0.61 J |
| Tetrahydrofuran | 13900 | 175000 | ND (2.5) | ND (0.31) | ND (0.31) | ND (0.31) | ND (0.31) | ND (0.31) | ND (0.31) | ND (0.31) | 0.75 | ND (0.31) |
| Toluene | 34800 | 438000 | 23 | 10 | 24 | 22 | 4.4 | 5.4 | 3.1 | 5.7 | 8.3 | 3.2 |
| 1,2,4-Trichlorobenzene | 13.9 | 175 | ND (5.6) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) |
| 1,1,1-Trichloroethane | 34800 | 438000 | ND (2.0) | ND (0.25) | 1.3 J | ND (0.25) | ND (0.25) | 2.6 | ND (0.25) | ND (0.25) | ND (0.25) | 0.30 J |
| 1,1,2-Trichloroethane | 1.39 | 17.5 | *ND (3.3)* | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) |
| Trichloroethylene; Trichloroethene; TCE | 13.9 | 175 | *29* | *880* | *6200* | *110* | 1.9 | 3.3 | 2.7 | 1.2 J | 2.5 | 2.2 |
| Trichlorofluoromethane | 4870 | 61300 | 16 J | 2.8 J | 2.6 J | 2.6 J | 2.7 J | 3.9 , J | 7.9 | 6.3 | 5.1 , J | 5.3 , J |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) | 209000 | 2630000 | 360 | 38 | 11 | 3.6 , J | 1.1 , J | 3.4 , J | 3.8 , J | 12 | 6.3 , J | 4.6 , J |
| 1,2,4-Trimethylbenzene | 48.7 | 613 | *600* | 22 | 26 | 21 | 9.4 | 19 | 20 | 18 | 12 | 9.1 |
| 1,3,5-Trimethylbenzene | ~ | ~ | 180 | 4.6 | 5.7 | 5.2 | 2.2 | 6.5 | 14 | 10 | 2.9 | 1.6 |
| Vinyl Acetate | 1390 | 17500 | ND (3.6) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) |
| Vinyl chloride; Chloroethene | 55.9 | 2790 | ND (2.2) | ND (0.27) | ND (0.27) | ND (0.27) | ND (0.27) | ND (0.27) | ND (0.27) | 0.35 J | 0.74 | ND (0.27) |
| Xylene, m&p | 695 | 8760 | *4900* | 18 | 27 | 25 | 9.0 | 18 | 9.9 | 91 | 8.1 | 15 |
| Xylene, o- | 695 | 8760 | *1900* | 8.4 | 11 | 10 | 4.1 | 13 | 9.2 | 50 | 3.5 | 7.4 |

NOTES:
1. ND = Not detected above the lab reporting limits shown in parenthesis.
2. NT = Not tested.
3. ~ = No IHSB Residential or Non-Residential screening limits limits.
6. Yellow Shaded values exceed the IHSB Residential Soil-Gas Screening Limits.
7. Red Shaded values exceed the IHSB Non-Residential Soil-Gas Screening Limits.
8. J = Estimated Value
9. B = Analyte found in the associated blank as well as the sample.

**TABLE D-1 (Page 2 of 5)**
**SUMMARY OF SUB-SLAB SOIL GAS SAMPLING TEST RESULTS**
**FORMER CORNING GLASS WORKS / AVX, INC.**
**3900 ELECTRONICS DRIVE**
**RALEIGH, NORTH CAROLINA**
**MID-ATLANTIC JOB NO. 000R2678.00**

| Parameter | Residential Vapor Intrusion Screening Levels | Non-Residential Vapor Intrusion Screening Levels | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Residential Soil-Gas ug/m3 | Non-Residential Soil-Gas ug/m3 | VP-19 | VP-2 | VP-20 | VP-21 | VP-22 | VP-23 | VP-24 | VP-25 | VP-26 |
| Sampling Date and Time | | | 7/16/2015 11:01 AM | 7/15/2015 11:17 AM | 7/16/2015 11:00 AM | 7/15/2015 3:53 PM | 7/15/2015 4:04 PM | 7/15/2015 4:50 PM | 7/16/2015 8:59 AM | 7/16/2015 9:17 AM | 7/16/2015 9:17 AM |
| ***EPA TO-15*** | | | | | | | | | | | |
| Acetone | 216000 | 2720000 | 49 | 1100 | 120 | ND (66) | 100 J | 200 | 61 | 110 | 58 |
| Benzene | 120 | 1570 | 0.62 J | 6.6 | 0.85 | ND (3.3) | ND (3.3) | 2.9 | 2.3 | 0.50 J | 0.45 J |
| Benzyl Chloride | 6.95 | 87.6 | ND (0.25) | ND (2.0) | ND (0.25) | ND (2.0) | ND (2.0) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) |
| Bromodichloromethane | 25.30 | 331 | ND (0.37) | ND (2.9) | ND (0.37) | ND (2.9) | ND (2.9) | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) |
| Bromoform | ~ | ~ | ND (0.50) | ND (4.0) | ND (0.50) | ND (4.0) | ND (4.0) | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) |
| Bromomethane | 34.8 | 438 | ND (0.67) | ND (5.3) | ND (0.67) | ND (5.3) | ND (5.3) | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) |
| 1,3-Butadiene | 13.9 | 175 | ND (0.28) | ND (2.3) | ND (0.28) | ND (2.3) | ND (2.3) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) |
| 2-Butanone (MEK) | 34800 | 438000 | 5.7 J | 13 J | 9.3 J | 8.6 J | 11 J | 18 J | 6.6 J | 8.6 J | 4.5 J |
| Carbon Disulfide | 4870 | 61300 | 1.7 J | ND (2.1) | 3.0 J | ND (2.1) | ND (2.1) | ND (0.27) | ND (0.27) | 1.5 J | 1.5 J |
| Carbon Tetrachloride | 156 | 2040 | ND (0.38) | ND (3.0) | ND (0.38) | ND (3.0) | ND (3.0) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) |
| Chlorobenzene | 348 | 4380 | ND (0.40) | ND (3.2) | ND (0.40) | ND (3.2) | ND (3.2) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) |
| Chloroethane | 69500 | 876000 | ND (0.25) | ND (2.0) | 0.82 | ND (2.0) | ND (2.0) | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) |
| Chloroform | 40.7 | 533 | 2.6 | *220* | 1.7 | *130* | *48* | *85* | *89* | 6.1 | 4.1 |
| Chloromethane | 626 | 7880 | 0.93 J | ND (1.8) | 9.9 | ND (1.8) | ND (1.8) | 2.4 | ND (0.23) | 0.64 J | 0.99 J |
| Cyclohexane | 41700 | 526000 | 2.8 | ND (4.0) | 2.3 | ND (4.0) | ND (4.0) | 4.3 | 2.0 | 2.8 | 1.4 |
| Dibromochloromethane | 34.70 | 454 | ND (0.57) | ND (4.5) | ND (0.57) | ND (4.5) | ND (4.5) | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) |
| 1,2-Dibromoethane (EDB) | 1.56 | 20.4 | ND (0.43) | *ND (3.4)* | ND (0.43) | *ND (3.4)* | *ND (3.4)* | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) |
| 1,2-Dichlorobenzene | 1390 | 17500 | ND (0.40) | ND (3.2) | ND (0.40) | ND (3.2) | ND (3.2) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) |
| 1,3-Dichlorobenzene | ~ | ~ | 9.5 | 30 | 3.4 | 46 | 15 | 18 | 5.2 | 23 | 7.4 |
| p-Dichlorobenzene; 1,4-Dichlorobenzene | 85.10 | 1110 | ND (0.38) | ND (3.0) | ND (0.38) | ND (3.0) | ND (3.0) | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) |
| Dichlorodifluoromethane (Freon 12) | 695 | 8760 | *9800* | *31000* | *9100* | 290 | 14 | 10 | 22 | 51 | 5.8 |
| 1,1-Dichloroethane | 585 | 7670 | ND (0.29) | ND (2.3) | ND (0.29) | ND (2.3) | ND (2.3) | 29 | 79 | ND (0.29) | ND (0.29) |
| 1,2-Dichloroethane | 36 | 472 | ND (0.28) | ND (2.3) | ND (0.28) | ND (2.3) | ND (2.3) | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) |
| 1,1-Dichloroethylene | 1390 | 17500 | ND (0.24) | ND (1.9) | ND (0.24) | ND (1.9) | ND (1.9) | ND (0.24) | 1.0 | ND (0.24) | ND (0.24) |
| cis-1,2-Dichloroethylene | ~ | ~ | ND (0.37) | 8.1 | ND (0.37) | 20 | ND (3.0) | 65 | 130 | ND (0.37) | ND (0.37) |
| trans-1,2-Dichloroethylene | | 5260 | ND (0.26) | 8.9 | ND (0.26) | 15 | ND (2.1) | 2.3 | 2.8 | ND (0.26) | ND (0.26) |
| 1,2-Dichloropropane | 27.8 | 350 | ND (0.40) | ND (3.2) | ND (0.40) | ND (3.2) | ND (3.2) | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) |
| cis-1,3-Dichloropropene | ~ | ~ | ND (0.30) | ND (2.4) | ND (0.30) | ND (2.4) | ND (2.4) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) |
| trans-1,3-Dichloropropene | ~ | ~ | ND (0.30) | ND (2.4) | ND (0.30) | ND (2.4) | ND (2.4) | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114) | ~ | ~ | ND (0.42) | ND (3.3) | ND (0.42) | ND (3.3) | ND (3.3) | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) |
| 1,4-Dioxane | ~ | ~ | ND (5.8) | ND (46) | ND (5.8) | ND (46) | ND (46) | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) |
| Ethanol | ~ | ~ | 110 | 630 | 120 | 260 | 270 | 400 | 330 | 330 | 140 |
| Ethyl Acetate | 487 | ~ | ND (0.67) | 17 | 2.7 | ND (5.4) | ND (5.4) | ND (0.67) | ND (0.67) | 3.3 | 2.0 |
| Ethylbenzene | 374 | 4910 | 7.9 | *2500* | 9.8 | 5.0 J | 4.0 J | 0.63 J | 0.87 J | 0.76 J | ND (0.30) |
| 4-Ethyltoluene | ~ | ~ | 0.84 J | 150 | 0.59 J | ND (2.2) | ND (2.2) | 0.64 J | 0.59 J | 0.96 J | ND (0.28) |
| Heptane | ~ | ~ | ND (0.33) | ND (2.7) | ND (0.33) | ND (2.7) | ND (2.7) | ND (0.33) | ND (0.33) | ND (0.33) | ND (0.33) |
| Hexachlorobutadiene | ~ | ~ | ND (1.0) | ND (8.0) | ND (1.0) | 11 , J | ND (8.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) |
| Hexane | 4870 | 61300 | ND (1.6) | ND (12) | ND (1.6) | ND (12) | ND (12) | 2.6 J | 3.7 J | 6.2 J | 1.7 J |
| 2-Hexanone (MBK) | 209 | 2630 | ND (0.26) | 4.6 J | ND (0.26) | ND (2.1) | ND (2.1) | 2.4 | ND (0.26) | ND (0.26) | ND (0.26) |
| Isopropanol | ~ | ~ | 30 | 2000 | 21 , J | 450 | 65 J | 130 | 200 | 55 | 22 , J |
| Methyl tert-Butyl Ether (MTBE) | 3600 | 47200 | 0.31 J | ND (2.2) | ND (0.28) | ND (2.2) | ND (2.2) | 0.79 J | ND (0.28) | ND (0.28) | 0.52 J |
| Methylene Chloride | 4170 | 52600 | ND (1.1) | ND (8.4) | 1.2 J | ND (8.4) | ND (8.4) | 1.8 J | 2.3 J | 2.2 J | 1.7 J |
| 4-Methyl-2-pentanone (MIBK) | 20900 | 263000 | ND (0.25) | 79 | ND (0.25) | ND (2.0) | ND (2.0) | 2.4 | 1.4 | 2.2 | ND (0.25) |
| Naphthalene | 20.9 | 263 | 17 | ND (5.7) | 16 | ND (5.7) | ND (5.7) | 1.2 J | 0.94 J | 0.81 J | 0.73 J |
| Propene | 20900 | 263000 | 3.0 J | ND (11) | 3.7 J | ND (11) | ND (11) | 8.7 J | 12 J | 4.2 J | 3.3 J |
| Styrene (Ethenylbenzene) | 6950 | 87600 | 0.34 J | 3.9 J | 0.38 J | ND (1.7) | ND (1.7) | 0.58 J | 0.30 J | 0.36 J | ND (0.21) |
| 1,1,2,2-Tetrachloroethane | 16.1 | 211 | ND (0.41) | ND (3.3) | ND (0.41) | ND (3.3) | ND (3.3) | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) |
| Tetrachloroethylene;Perchloroethylene | 278 | 3500 | 5.7 | 37 | 55 | 63 | 39 | *480* | *1000* | 6.1 | 21 |
| Tetrahydrofuran | 13900 | 175000 | ND (0.31) | 70 | ND (0.31) | ND (2.5) | ND (2.5) | ND (0.31) | ND (0.31) | ND (0.31) | ND (0.31) |
| Toluene | 34800 | 438000 | 1.3 | 120 | 1.9 | 2.6 J | ND (2.3) | 1.7 | 1.0 | 1.2 | 0.98 |
| 1,2,4-Trichlorobenzene | 13.9 | 175 | ND (0.70) | ND (5.6) | ND (0.70) | ND (5.6) | ND (5.6) | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) |
| 1,1,1-Trichloroethane | 34800 | 438000 | ND (0.25) | ND (2.0) | ND (0.25) | ND (2.0) | ND (2.0) | 2.1 | 1.1 J | ND (0.25) | ND (0.25) |
| 1,1,2-Trichloroethane | 1.39 | 17.5 | ND (0.41) | *ND (3.3)* | ND (0.41) | *ND (3.3)* | *ND (3.3)* | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) |
| Trichloroethylene; Trichloroethene; TCE | 13.9 | 175 | *220* | *54000* | *570* | *120000* | *16000* | *6000 B* | *4000 B* | *180* | 6.9 |
| Trichlorofluoromethane | 4870 | 61300 | 3.2 J | 42 J | 2.1 J | 28 , J | 19 , J | 12 | 14 | 5.3 J | 2.5 J |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) | 209000 | 2630000 | 20 | 500 | 11 | 420 | 240 | 1900 | 3600 | 22 | 7.2 , J |
| 1,2,4-Trimethylbenzene | 48.7 | 613 | 3.4 | *790* | 2.1 | 13 | 13 | 5.4 | 5.9 | 3.3 | 5.7 |
| 1,3,5-Trimethylbenzene | ~ | ~ | 0.54 J | 340 | 0.47 J | ND (2.0) | ND (2.0) | 0.93 J | 0.37 J | 0.52 J | ND (0.25) |
| Vinyl Acetate | 1390 | 17500 | ND (0.45) | ND (3.6) | ND (0.45) | ND (3.6) | ND (3.6) | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) |
| Vinyl chloride; Chloroethene | 55.9 | 2790 | ND (0.27) | ND (2.2) | ND (0.27) | ND (2.2) | ND (2.2) | ND (0.27) | ND (0.27) | ND (0.27) | ND (0.27) |
| Xylene, m&p | 695 | 8760 | 47 | *6400* | 51 | 16 J | 14 J | 2.5 | 3.9 | 3.0 | 1.0 J |
| Xylene, o- | 695 | 8760 | 17 | *3300* | 19 | 8.9 | 6.6 J | 1.2 | 1.4 | 1.4 | 0.54 J |

NOTES:
1. ND = Not detected above the lab reporting limits shown in parenthesis.
2. NT = Not tested.
3. ~ = No IHSB Residential or Non-Residential screening limits limits.
6. Yellow Shaded values exceed the IHSB Residential Soil-Gas Screening Limits.
7. Red Shaded values exceed the IHSB Non-Residential Soil-Gas Screening Limits.
8. J = Estimated Value.
9. B = Analyte found in the associated blank as well as the sample.

**TABLE D-1 (Page 3 of 5)**
**SUMMARY OF SUB-SLAB SOIL GAS SAMPLING TEST RESULTS**
**FORMER CORNING GLASS WORKS / AVX, INC.**
**3900 ELECTRONICS DRIVE**
**RALEIGH, NORTH CAROLINA**
**MID-ATLANTIC JOB NO. 000R2678.00**

| Parameter | Residential Vapor Intrusion Screening Levels | Non-Residential Vapor Intrusion Screening Levels | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Residential Soil-Gas ug/m3 | Non-Residential Soil-Gas ug/m3 | VP-27 | VP-28 | VP-29 | VP-3 | VP-30 | VP-31 | VP-32 | VP-33 | VP-34 |
| Sampling Date and Time | | | 7/16/2015 9:38 AM | 7/16/2015 9:32 AM | 7/15/2015 5:04 PM | 7/15/2015 10:48 AM | 7/15/2015 4:36 PM | 7/15/2015 4:22 PM | 7/15/2015 3:04 PM | 7/15/2015 3:36 PM | 7/16/2015 9:45 AM |
| ***EPA TO-15*** | | | | | | | | | | | |
| Acetone | 216000 | 2720000 | 86 | 77 | 220 | 480 | 89 J | 90 J | 95 J | 120 J | ND (66) |
| Benzene | 120 | 1570 | 0.42 J | ND (0.41) | 2.8 | ND (0.41) | ND (3.3) | 4.1 J | ND (3.3) | ND (3.3) | ND (3.3) |
| Benzyl Chloride | 6.95 | 87.6 | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) |
| Bromodichloromethane | 25.30 | 331 | ND (0.37) | ND (0.37) | ND (0.37) | ND (0.37) | ND (2.9) | ND (2.9) | ND (2.9) | ND (2.9) | ND (2.9) |
| Bromoform | ~ | ~ | ND (0.50) | ND (0.50) | ND (0.50) | ND (0.50) | ND (4.0) | ND (4.0) | ND (4.0) | ND (4.0) | ND (4.0) |
| Bromomethane | 34.8 | 438 | ND (0.67) | ND (0.67) | ND (0.67) | ND (0.67) | ND (5.3) | ND (5.3) | ND (5.3) | ND (5.3) | ND (5.3) |
| 1,3-Butadiene | 13.9 | 175 | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) |
| 2-Butanone (MEK) | 34800 | 438000 | 7.7 J | 8.2 J | 54 | 21 J | 12 J | 12 J | 20 J | 16 J | 9.3 J |
| Carbon Disulfide | 4870 | 61300 | ND (0.27) | ND (0.27) | ND (0.27) | ND (0.27) | ND (2.1) | ND (2.1) | ND (2.1) | ND (2.1) | 2.6 J |
| Carbon Tetrachloride | 156 | 2040 | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | 4.3 J | 17 | 4.8 J | ND (3.0) | ND (3.0) |
| Chlorobenzene | 348 | 4380 | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) |
| Chloroethane | 69500 | 876000 | ND (0.25) | ND (0.25) | ND (0.25) | ND (0.25) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) |
| Chloroform | 40.7 | 533 | 0.61 J | 2.8 | *41* | 15 | 37 | *380* | *250* | *45* | 20 |
| Chloromethane | 626 | 7880 | 0.50 J | 0.57 J | ND (0.23) | 0.50 J | ND (1.8) | ND (1.8) | ND (1.8) | ND (1.8) | ND (1.8) |
| Cyclohexane | 41700 | 526000 | 3.1 | 2.8 | 3.3 | 3.1 | ND (4.0) | ND (4.0) | ND (4.0) | ND (4.0) | ND (4.0) |
| Dibromochloromethane | 34.70 | 454 | ND (0.57) | ND (0.57) | ND (0.57) | ND (0.57) | ND (4.5) | ND (4.5) | ND (4.5) | ND (4.5) | ND (4.5) |
| 1,2-Dibromoethane (EDB) | 1.56 | 20.4 | ND (0.43) | ND (0.43) | ND (0.43) | ND (0.43) | *ND (3.4)* | *ND (3.4)* | *ND (3.4)* | *ND (3.4)* | *ND (3.4)* |
| 1,2-Dichlorobenzene | 1390 | 17500 | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) |
| 1,3-Dichlorobenzene | ~ | ~ | 6.8 | 4.9 | 8.9 | 35 | 22 | 97 | 74 | 21 | 6.3 J |
| p-Dichlorobenzene; 1,4-Dichlorobenzene | 85.10 | 1110 | ND (0.38) | ND (0.38) | ND (0.38) | ND (0.38) | ND (3.0) | ND (3.0) | ND (3.0) | ND (3.0) | 6.3 J |
| Dichlorodifluoromethane (Freon 12) | 695 | 8760 | 15 | 17 | 7.5 | *9400* | 11 | 50 | 120 | 32 | 19 |
| 1,1-Dichloroethane | 585 | 7670 | ND (0.29) | ND (0.29) | 190 | ND (0.29) | 2.8 J | ND (2.3) | ND (2.3) | ND (2.3) | 2.4 J |
| 1,2-Dichloroethane | 36 | 472 | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) |
| 1,1-Dichloroethylene | 1390 | 17500 | ND (0.24) | ND (0.24) | 3.1 | ND (0.24) | ND (1.9) | 29 | 3.0 J | ND (1.9) | ND (1.9) |
| cis-1,2-Dichloroethylene | ~ | ~ | ND (0.37) | ND (0.37) | 140 | ND (0.37) | 23 | 350 | 58 | 6.8 J | ND (3.0) |
| trans-1,2-Dichloroethylene | | 5260 | ND (0.26) | ND (0.26) | 7.9 | ND (0.26) | 24 | 260 | 43 | 7.3 J | 4.8 J |
| 1,2-Dichloropropane | 27.8 | 350 | ND (0.40) | ND (0.40) | ND (0.40) | ND (0.40) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) |
| cis-1,3-Dichloropropene | ~ | ~ | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) |
| trans-1,3-Dichloropropene | ~ | ~ | ND (0.30) | ND (0.30) | ND (0.30) | ND (0.30) | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114) | ~ | ~ | ND (0.42) | ND (0.42) | ND (0.42) | ND (0.42) | ND (3.3) | ND (3.3) | ND (3.3) | ND (3.3) | ND (3.3) |
| 1,4-Dioxane | ~ | ~ | ND (5.8) | ND (5.8) | ND (5.8) | ND (5.8) | ND (46) | ND (46) | ND (46) | ND (46) | ND (46) |
| Ethanol | ~ | ~ | 190 , | 130 | 900 | 1000 | 450 | 1300 | 250 | 270 | 270 |
| Ethyl Acetate | 487 | ~ | 2.9 | 6.0 | 1.8 | 17 | ND (5.4) | ND (5.4) | ND (5.4) | ND (5.4) | ND (5.4) |
| Ethylbenzene | 374 | 4910 | 0.48 J | 0.41 J | 0.91 J | 3.3 | ND (2.4) | ND (2.4) | 3.8 J | 2.4 J | ND (2.4) |
| 4-Ethyltoluene | ~ | ~ | 0.74 J | 0.71 J | 0.81 J | 5.8 | ND (2.2) | ND (2.2) | ND (2.2) | ND (2.2) | ND (2.2) |
| Heptane | ~ | ~ | ND (0.33) | ND (0.33) | ND (0.33) | ND (0.33) | ND (2.7) | ND (2.7) | 6.1 J | 19 | ND (2.7) |
| Hexachlorobutadiene | ~ | ~ | ND (1.0) | ND (1.0) | ND (1.0) | ND (1.0) | ND (8.0) | 8.1 , J | ND (8.0) | 21 | ND (8.0) |
| Hexane | 4870 | 61300 | 5.0 J | ND (1.6) | 6.3 J | 1.8 J | ND (12) | ND (12) | 230 J | 870 | ND (12) |
| 2-Hexanone (MBK) | 209 | 2630 | 2.9 | ND (0.26) | 4.8 | 5.9 | ND (2.1) | ND (2.1) | ND (2.1) | ND (2.1) | ND (2.1) |
| Isopropanol | ~ | ~ | 36 | 41 | 110 | 520 | 63 J | 990 | 2100 | 560 | 27 J |
| Methyl tert-Butyl Ether (MTBE) | 3600 | 47200 | ND (0.28) | ND (0.28) | ND (0.28) | ND (0.28) | ND (2.2) | ND (2.2) | 3.9 J | ND (2.2) | ND (2.2) |
| Methylene Chloride | 4170 | 52600 | 1.2 J | ND (1.1) | 2.4 J | 1.3 J | ND (8.4) | ND (8.4) | ND (8.4) | ND (8.4) | ND (8.4) |
| 4-Methyl-2-pentanone (MIBK) | 20900 | 263000 | 5.4 | 1.8 | 2.5 | 7.8 | ND (2.0) | 5.2 J | ND (2.0) | ND (2.0) | ND (2.0) |
| Naphthalene | 20.9 | 263 | ND (0.71) | 0.89 J | 0.92 J | 4.6 | ND (5.7) | ND (5.7) | ND (5.7) | ND (5.7) | ND (5.7) |
| Propene | 20900 | 263000 | 2.5 J | 3.1 J | 8.2 J | 5.0 J | 14 J | ND (11) | ND (11) | ND (11) | 12 J |
| Styrene (Ethenylbenzene) | 6950 | 87600 | 0.66 J | 0.47 J | 0.62 J | 1.6 | ND (1.7) | ND (1.7) | ND (1.7) | ND (1.7) | ND (1.7) |
| 1,1,2,2-Tetrachloroethane | 16.1 | 211 | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | ND (3.3) | ND (3.3) | ND (3.3) | ND (3.3) | ND (3.3) |
| Tetrachloroethylene;Perchloroethylene | 278 | 3500 | 3.1 | 61 | *770* | 12 | 150 | *400* | 49 | 25 | 51 |
| Tetrahydrofuran | 13900 | 175000 | ND (0.31) | ND (0.31) | ND (0.31) | ND (0.31) | ND (2.5) | ND (2.5) | ND (2.5) | ND (2.5) | ND (2.5) |
| Toluene | 34800 | 438000 | 1.6 | 1.4 | 3.2 | 6.5 | ND (2.3) | 3.8 J | 5.4 J | 3.0 J | ND (2.3) |
| 1,2,4-Trichlorobenzene | 13.9 | 175 | ND (0.70) | ND (0.70) | ND (0.70) | ND (0.70) | ND (5.6) | ND (5.6) | ND (5.6) | ND (5.6) | ND (5.6) |
| 1,1,1-Trichloroethane | 34800 | 438000 | ND (0.25) | ND (0.25) | ND (0.25) | 5.2 | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) |
| 1,1,2-Trichloroethane | 1.39 | 17.5 | ND (0.41) | ND (0.41) | ND (0.41) | ND (0.41) | *ND (3.3)* | *ND (3.3)* | *11* | *ND (3.3)* | *ND (3.3)* |
| Trichloroethylene; Trichloroethene; TCE | 13.9 | 175 | 6.9 | *320* | *8600 B* | *2700* | *130000* | *880000* | *140000* | *41000* | *32000* |
| Trichlorofluoromethane | 4870 | 61300 | 6.5 | 8.0 | 23 | 14 | 33 , J | 90 | 23 J | 21 , J | 20 , J |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) | 209000 | 2630000 | 960 | 52 | 1500 | 880 | 380 | 2600 | 420 | 230 | 62 |
| 1,2,4-Trimethylbenzene | 48.7 | 613 | 7.5 | 4.1 | 4.8 | 38 | 11 | 27 | 29 | 14 | 3.9 J |
| 1,3,5-Trimethylbenzene | ~ | ~ | 0.47 J | 0.81 J | 1.0 J | 10 | ND (2.0) | 2.6 J | 3.5 J | ND (2.0) | ND (2.0) |
| Vinyl Acetate | 1390 | 17500 | ND (0.45) | ND (0.45) | ND (0.45) | ND (0.45) | ND (3.6) | ND (3.6) | ND (3.6) | ND (3.6) | ND (3.6) |
| Vinyl chloride; Chloroethene | 55.9 | 2790 | ND (0.27) | ND (0.27) | 0.73 | ND (0.27) | ND (2.2) | ND (2.2) | ND (2.2) | ND (2.2) | ND (2.2) |
| Xylene, m&p | 695 | 8760 | 1.6 J | 1.5 J | 3.3 | 13 | ND (4.4) | 7.5 J | 16 J | 9.9 J | ND (4.4) |
| Xylene, o- | 695 | 8760 | 0.74 J | 1.2 | 1.5 | 6.9 | ND (2.5) | 4.3 J | 6.9 J | 4.0 J | ND (2.5) |

NOTES:
1. ND = Not detected above the lab reporting limits shown in parenthesis.
2. NT = Not tested.
3. ~ = No IHSB Residential or Non-Residential screening limits limits.
6. Yellow Shaded values exceed the IHSB Residential Soil-Gas Screening Limits.
7. Red Shaded values exceed the IHSB Non-Residential Soil-Gas Screening Limits.
8. J = Estimated Value
9. B = Analyte found in the associated blank as well as the sample.

**TABLE D-1 (Page 4 of 5)**
**SUMMARY OF SUB-SLAB SOIL GAS SAMPLING TEST RESULTS**
**FORMER CORNING GLASS WORKS / AVX, INC.**
**3900 ELECTRONICS DRIVE**
**RALEIGH, NORTH CAROLINA**
**MID-ATLANTIC JOB NO. 000R2678.00**

| Parameter | Residential Vapor Intrusion Screening Levels | Non-Residential Vapor Intrusion Screening Levels | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Residential Soil-Gas ug/m3 | Non-Residential Soil-Gas ug/m3 | VP-35 | VP-36 | VP-37 | VP-38 | VP-39 | VP-4 | VP-40 | VP-5 | VP-6 |
| Sampling Date and Time | | | 7/16/2015 9:57 AM | 7/16/2015 10:26 AM | 7/16/2015 10:30 AM | 7/16/2015 10:43 AM | 7/16/2015 10:44 AM | 7/15/2015 10:32 AM | 7/15/2015 3:23 PM | 7/15/2015 10:10 AM | 7/15/2015 9:23 AM |
| ***EPA TO-15*** | | | | | | | | | | | |
| Acetone | 216000 | 2720000 | 290 | 40 | 160 | 260 | 160 J | 280 | 890 | ND (8.2) | 1300 |
| Benzene | 120 | 1570 | 0.70 J | 0.77 J | 2.9 | ND (3.3) | ND (3.3) | 8.9 | ND (3.3) | ND (0.41) | ND (3.3) |
| Benzyl Chloride | 6.95 | 87.6 | ND (0.25) | ND (0.25) | ND (0.25) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) | ND (0.25) | ND (2.0) |
| Bromodichloromethane | 25.30 | 331 | ND (0.37) | ND (0.37) | ND (0.37) | ND (2.9) | ND (2.9) | ND (2.9) | ND (2.9) | ND (0.37) | ND (2.9) |
| Bromoform | ~ | ~ | ND (0.50) | ND (0.50) | ND (0.50) | ND (4.0) | ND (4.0) | ND (4.0) | ND (4.0) | ND (0.50) | ND (4.0) |
| Bromomethane | 34.8 | 438 | ND (0.67) | ND (0.67) | ND (0.67) | ND (5.3) | ND (5.3) | ND (5.3) | ND (5.3) | ND (0.67) | ND (5.3) |
| 1,3-Butadiene | 13.9 | 175 | ND (0.28) | ND (0.28) | ND (0.28) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) | ND (0.28) | ND (2.3) |
| 2-Butanone (MEK) | 34800 | 438000 | 8.3 J | 2.0 J | 10 J | 22 J | 17 J | 23 J | 60 J | 8.1 J | 90 J |
| Carbon Disulfide | 4870 | 61300 | ND (0.27) | ND (0.27) | 1.3 J | ND (2.1) | 10 J | ND (2.1) | 3.6 J | ND (0.27) | ND (2.1) |
| Carbon Tetrachloride | 156 | 2040 | ND (0.38) | ND (0.38) | ND (0.38) | ND (3.0) | ND (3.0) | ND (3.0) | 4.3 J | ND (0.38) | ND (3.0) |
| Chlorobenzene | 348 | 4380 | ND (0.40) | ND (0.40) | ND (0.40) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) | ND (0.40) | ND (3.2) |
| Chloroethane | 69500 | 876000 | ND (0.25) | ND (0.25) | ND (0.25) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) | ND (0.25) | ND (2.0) |
| Chloroform | 40.7 | 533 | 1.2 J | 1.1 J | 0.68 J | 7.6 J | 25 | *3000* | *540* | ND (0.29) | ND (2.3) |
| Chloromethane | 626 | 7880 | 0.59 J | 0.42 J | 1.4 | ND (1.8) | ND (1.8) | ND (1.8) | ND (1.8) | 0.85 J | ND (1.8) |
| Cyclohexane | 41700 | 526000 | 3.6 | ND (0.49) | 4.3 | ND (4.0) | ND (4.0) | ND (4.0) | ND (4.0) | ND (0.49) | ND (4.0) |
| Dibromochloromethane | 34.70 | 454 | ND (0.57) | ND (0.57) | ND (0.57) | ND (4.5) | ND (4.5) | ND (4.5) | ND (4.5) | ND (0.57) | ND (4.5) |
| 1,2-Dibromoethane (EDB) | 1.56 | 20.4 | ND (0.43) | ND (0.43) | ND (0.43) | *ND (3.4)* | *ND (3.4)* | *ND (3.4)* | *ND (3.4)* | ND (0.43) | *ND (3.4)* |
| 1,2-Dichlorobenzene | 1390 | 17500 | ND (0.40) | ND (0.40) | ND (0.40) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) | ND (0.40) | ND (3.2) |
| 1,3-Dichlorobenzene | ~ | ~ | 25 | 4.4 | 7.2 | 12 | 32 | 48 | 32 | 34 | 28 |
| p-Dichlorobenzene; 1,4-Dichlorobenzene | 85.10 | 1110 | ND (0.38) | ND (0.38) | ND (0.38) | ND (3.0) | ND (3.0) | ND (3.0) | ND (3.0) | ND (0.38) | 28 |
| Dichlorodifluoromethane (Freon 12) | 695 | 8760 | 13 | 22 | 17 | 42 | 33 | *8200* | 46 | 490 | 100 |
| 1,1-Dichloroethane | 585 | 7670 | ND (0.29) | ND (0.29) | ND (0.29) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) | ND (0.29) | ND (2.3) |
| 1,2-Dichloroethane | 36 | 472 | ND (0.28) | ND (0.28) | ND (0.28) | ND (2.3) | ND (2.3) | ND (2.3) | ND (2.3) | ND (0.28) | ND (2.3) |
| 1,1-Dichloroethylene | 1390 | 17500 | ND (0.24) | ND (0.24) | ND (0.24) | ND (1.9) | ND (1.9) | ND (1.9) | 15 | ND (0.24) | ND (1.9) |
| cis-1,2-Dichloroethylene | ~ | ~ | ND (0.37) | ND (0.37) | ND (0.37) | 3.0 J | 6.8 J | ND (3.0) | 72 | ND (0.37) | ND (3.0) |
| trans-1,2-Dichloroethylene | | 5260 | ND (0.26) | ND (0.26) | ND (0.26) | 3.5 J | 3.8 J | 5.4 J | 67 | ND (0.26) | ND (2.1) |
| 1,2-Dichloropropane | 27.8 | 350 | ND (0.40) | ND (0.40) | ND (0.40) | ND (3.2) | ND (3.2) | ND (3.2) | ND (3.2) | ND (0.40) | ND (3.2) |
| cis-1,3-Dichloropropene | ~ | ~ | ND (0.30) | ND (0.30) | ND (0.30) | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) | ND (0.30) | ND (2.4) |
| trans-1,3-Dichloropropene | ~ | ~ | ND (0.30) | ND (0.30) | ND (0.30) | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) | ND (0.30) | ND (2.4) |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114) | ~ | ~ | ND (0.42) | ND (0.42) | ND (0.42) | ND (3.3) | ND (3.3) | ND (3.3) | ND (3.3) | ND (0.42) | ND (3.3) |
| 1,4-Dioxane | ~ | ~ | ND (5.8) | ND (5.8) | ND (5.8) | ND (46) | ND (46) | ND (46) | ND (46) | ND (5.8) | ND (46) |
| Ethanol | ~ | ~ | 470 | 63 | 240 | 470 | 150 | 1100 | 1100 | 330 | 1600 |
| Ethyl Acetate | 487 | ~ | 3.1 | 2.2 | 2.1 | ND (5.4) | ND (5.4) | ND (5.4) | ND (5.4) | 26 | ND (5.4) |
| Ethylbenzene | 374 | 4910 | 250 | 14 | 1.3 | ND (2.4) | ND (2.4) | ND (2.4) | ND (2.4) | 0.76 J | 2.8 J |
| 4-Ethyltoluene | ~ | ~ | 3.1 | 0.76 J | 0.66 J | ND (2.2) | ND (2.2) | ND (2.2) | 16 | 0.88 J | 2.9 J |
| Heptane | ~ | ~ | ND (0.33) | ND (0.33) | ND (0.33) | ND (2.7) | ND (2.7) | ND (2.7) | ND (2.7) | ND (0.33) | ND (2.7) |
| Hexachlorobutadiene | ~ | ~ | ND (1.0) | ND (1.0) | ND (1.0) | 17 J | ND (8.0) | ND (8.0) | ND (8.0) | ND (1.0) | ND (8.0) |
| Hexane | 4870 | 61300 | ND (1.6) | 2.0 J | 11 J | ND (12) | 61 J | ND (12) | ND (12) | ND (1.6) | ND (12) |
| 2-Hexanone (MBK) | 209 | 2630 | ND (0.26) | ND (0.26) | 4.8 | ND (2.1) | ND (2.1) | ND (2.1) | ND (2.1) | 1.4 | 9.8 |
| Isopropanol | ~ | ~ | 99 | 36 | 150 , | 93 J | 1600 | 600 | 2100 | 58 | 2100 |
| Methyl tert-Butyl Ether (MTBE) | 3600 | 47200 | ND (0.28) | ND (0.28) | ND (0.28) | 37 | ND (2.2) | ND (2.2) | ND (2.2) | 0.65 J | ND (2.2) |
| Methylene Chloride | 4170 | 52600 | 1.3 J | 2.0 J | 1.7 J | ND (8.4) | ND (8.4) | ND (8.4) | ND (8.4) | ND (1.1) | ND (8.4) |
| 4-Methyl-2-pentanone (MIBK) | 20900 | 263000 | 8.2 | 7.2 | ND (0.25) | ND (2.0) | ND (2.0) | 8.8 | 7.4 J | 1.9 | 11 |
| Naphthalene | 20.9 | 263 | 0.89 J | ND (0.71) | 0.97 J | ND (5.7) | ND (5.7) | ND (5.7) | ND (5.7) | 1.7 | ND (5.7) |
| Propene | 20900 | 263000 | 3.1 J | ND (1.3) | 3.5 J | ND (11) | 18 J | ND (11) | ND (11) | 4.4 J | 12 J |
| Styrene (Ethenylbenzene) | 6950 | 87600 | 0.66 J | ND (0.21) | 0.58 J | ND (1.7) | ND (1.7) | ND (1.7) | ND (1.7) | 0.81 J | ND (1.7) |
| 1,1,2,2-Tetrachloroethane | 16.1 | 211 | ND (0.41) | ND (0.41) | ND (0.41) | ND (3.3) | ND (3.3) | ND (3.3) | ND (3.3) | ND (0.41) | ND (3.3) |
| Tetrachloroethylene;Perchloroethylene | 278 | 3500 | 20 | 22 | 12 | 63 | 10 J | 83 | 100 | 39 | *320* |
| Tetrahydrofuran | 13900 | 175000 | ND (0.31) | ND (0.31) | ND (0.31) | ND (2.5) | ND (2.5) | ND (2.5) | ND (2.5) | ND (0.31) | ND (2.5) |
| Toluene | 34800 | 438000 | 3.7 | 1.9 | 1.4 | ND (2.3) | ND (2.3) | 4.8 J | 3.8 J | 2.6 | ND (2.3) |
| 1,2,4-Trichlorobenzene | 13.9 | 175 | ND (0.70) | ND (0.70) | ND (0.70) | ND (5.6) | ND (5.6) | ND (5.6) | ND (5.6) | ND (0.70) | ND (5.6) |
| 1,1,1-Trichloroethane | 34800 | 438000 | 0.90 J | ND (0.25) | ND (0.25) | ND (2.0) | ND (2.0) | ND (2.0) | ND (2.0) | 1.3 J | ND (2.0) |
| 1,1,2-Trichloroethane | 1.39 | 17.5 | ND (0.41) | ND (0.41) | ND (0.41) | *ND (3.3)* | *ND (3.3)* | *ND (3.3)* | *15* | ND (0.41) | *ND (3.3)* |
| Trichloroethylene; Trichloroethene; TCE | 13.9 | 175 | *29* | *27* | *17* | *34000* | *15000* | *35000* | *210000* | 1.6 | 3.4 J |
| Trichlorofluoromethane | 4870 | 61300 | 7.2 | 8.6 | 9.6 | 22 , , J | 52 | 12 J | 16 J | 12 | 7.2 J |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) | 209000 | 2630000 | 93 | 120 | 8.1 | 74 | 11 J | 1600 | 120 | 2900 | 1000 |
| 1,2,4-Trimethylbenzene | 48.7 | 613 | 5.6 | 3.0 | 8.4 | 5.3 J | 11 | 19 | *64* | 9.1 | 22 |
| 1,3,5-Trimethylbenzene | ~ | ~ | 1.7 | 0.52 J | 0.61 J | ND (2.0) | ND (2.0) | 2.9 J | 38 | 1.2 | 2.4 J |
| Vinyl Acetate | 1390 | 17500 | ND (0.45) | ND (0.45) | ND (0.45) | ND (3.6) | ND (3.6) | ND (3.6) | ND (3.6) | ND (0.45) | ND (3.6) |
| Vinyl chloride; Chloroethene | 55.9 | 2790 | ND (0.27) | ND (0.27) | ND (0.27) | ND (2.2) | ND (2.2) | ND (2.2) | ND (2.2) | ND (0.27) | ND (2.2) |
| Xylene, m&p | 695 | 8760 | 540 | 42 | 4.9 | ND (4.4) | ND (4.4) | 5.6 J | 9.0 J | 2.6 | 9.7 J |
| Xylene, o- | 695 | 8760 | 410 | 5.3 | 2.2 | ND (2.5) | ND (2.5) | ND (2.5) | 16 | 1.5 | 5.0 J |

NOTES:
1. ND = Not detected above the lab reporting limits shown in parenthesis.
2. NT = Not tested.
3. ~ = No IHSB Residential or Non-Residential screening limits limits.
6. Yellow Shaded values exceed the IHSB Residential Soil-Gas Screening Limits.
7. Red Shaded values exceed the IHSB Non-Residential Soil-Gas Screening Limits.
8. J = Estimated Value
9. B = Analyte found in the associated blank as well as the sample.

**TABLE D-1 (Page 5 of 5)**
**SUMMARY OF SUB-SLAB SOIL GAS SAMPLING TEST RESULTS**
**FORMER CORNING GLASS WORKS / AVX, INC.**
**3900 ELECTRONICS DRIVE**
**RALEIGH, NORTH CAROLINA**
**MID-ATLANTIC JOB NO. 000R2678.00**

| Parameter | Residential Vapor Intrusion Screening Levels | Non-Residential Vapor Intrusion Screening Levels | | | |
|---|---|---|---|---|---|
| | Residential Soil-Gas ug/m3 | Non-Residential Soil-Gas ug/m3 | VP-7 | VP-8 | VP-9 |
| Sampling Date and Time | | | 7/14/2015 5:03 PM | 7/14/2015 4:46 PM | 7/14/2015 4:24 PM |
| ***EPA TO-15*** | | | | | |
| Acetone | 216000 | 2720000 | 310 | 1100 | 460 |
| Benzene | 120 | 1570 | 3.3 J | ND (0.41) | 3.6 J |
| Benzyl Chloride | 6.95 | 87.6 | ND (2.0) | ND (0.25) | ND (2.0) |
| Bromodichloromethane | 25.30 | 331 | ND (2.9) | ND (0.37) | ND (2.9) |
| Bromoform | ~ | ~ | ND (4.0) | ND (0.50) | ND (4.0) |
| Bromomethane | 34.8 | 438 | ND (5.3) | ND (0.67) | ND (5.3) |
| 1,3-Butadiene | 13.9 | 175 | ND (2.3) | ND (0.28) | ND (2.3) |
| 2-Butanone (MEK) | 34800 | 438000 | 47 J | 24 J | 49 J |
| Carbon Disulfide | 4870 | 61300 | ND (2.1) | 1.8 J | ND (2.1) |
| Carbon Tetrachloride | 156 | 2040 | ND (3.0) | ND (0.38) | 6.8 J |
| Chlorobenzene | 348 | 4380 | ND (3.2) | ND (0.40) | ND (3.2) |
| Chloroethane | 69500 | 876000 | ND (2.0) | ND (0.25) | ND (2.0) |
| Chloroform | 40.7 | 533 | ND (2.3) | *41* | *590* |
| Chloromethane | 626 | 7880 | ND (1.8) | 0.66 J | ND (1.8) |
| Cyclohexane | 41700 | 526000 | ND (4.0) | 15 | ND (4.0) |
| Dibromochloromethane | 34.70 | 454 | ND (4.5) | ND (0.57) | ND (4.5) |
| 1,2-Dibromoethane (EDB) | 1.56 | 20.4 | *ND (3.4)* | ND (0.43) | *ND (3.4)* |
| 1,2-Dichlorobenzene | 1390 | 17500 | ND (3.2) | ND (0.40) | ND (3.2) |
| 1,3-Dichlorobenzene | ~ | ~ | 160 | 33 | 67 |
| p-Dichlorobenzene; 1,4-Dichlorobenzene | 85.10 | 1110 | ND (3.0) | ND (0.38) | ND (3.0) |
| Dichlorodifluoromethane (Freon 12) | 695 | 8760 | 69 | 4.4 L-05 | 6.7 J |
| 1,1-Dichloroethane | 585 | 7670 | ND (2.3) | ND (0.29) | ND (2.3) |
| 1,2-Dichloroethane | 36 | 472 | ND (2.3) | ND (0.28) | ND (2.3) |
| 1,1-Dichloroethylene | 1390 | 17500 | ND (1.9) | ND (0.24) | ND (1.9) |
| cis-1,2-Dichloroethylene | ~ | ~ | ND (3.0) | ND (0.37) | ND (3.0) |
| trans-1,2-Dichloroethylene | | 5260 | ND (2.1) | ND (0.26) | 5.4 J |
| 1,2-Dichloropropane | 27.8 | 350 | ND (3.2) | ND (0.40) | ND (3.2) |
| cis-1,3-Dichloropropene | ~ | ~ | ND (2.4) | ND (0.30) | ND (2.4) |
| trans-1,3-Dichloropropene | ~ | ~ | ND (2.4) | ND (0.30) | ND (2.4) |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114) | ~ | ~ | ND (3.3) | ND (0.42) | ND (3.3) |
| 1,4-Dioxane | ~ | ~ | ND (46) | ND (5.8) | ND (46) |
| Ethanol | ~ | ~ | 1600 | 1600 | 860 |
| Ethyl Acetate | 487 | ~ | ND (5.4) | 3.3 | ND (5.4) |
| Ethylbenzene | 374 | 4910 | 12 | 4.3 | 8.5 J |
| 4-Ethyltoluene | ~ | ~ | 6.3 J | 2.7 | 3.3 J |
| Heptane | ~ | ~ | ND (2.7) | 0.94 J | ND (2.7) |
| Hexachlorobutadiene | ~ | ~ | ND (8.0) | ND (1.0) | ND (8.0) |
| Hexane | 4870 | 61300 | ND (12) | 2.1 J | ND (12) |
| 2-Hexanone (MBK) | 209 | 2630 | 7.0 J | 2.3 | 9.2 |
| Isopropanol | ~ | ~ | 12000 | 7800 | 5900 |
| Methyl tert-Butyl Ether (MTBE) | 3600 | 47200 | 11 | 5.1 | 6.8 J |
| Methylene Chloride | 4170 | 52600 | ND (8.4) | 1.7 J | ND (8.4) |
| 4-Methyl-2-pentanone (MIBK) | 20900 | 263000 | 15 | 7.2 | ND (2.0) |
| Naphthalene | 20.9 | 263 | ND (5.7) | 1.4 | ND (5.7) |
| Propene | 20900 | 263000 | ND (11) | 13 J | ND (11) |
| Styrene (Ethenylbenzene) | 6950 | 87600 | 1.9 J | 1.1 | ND (1.7) |
| 1,1,2,2-Tetrachloroethane | 16.1 | 211 | ND (3.3) | ND (0.41) | ND (3.3) |
| Tetrachloroethylene;Perchloroethylene | 278 | 3500 | 100 | 16 | 120 |
| Tetrahydrofuran | 13900 | 175000 | ND (2.5) | ND (0.31) | ND (2.5) |
| Toluene | 34800 | 438000 | 34 | 17 | 23 |
| 1,2,4-Trichlorobenzene | 13.9 | 175 | ND (5.6) | ND (0.70) | ND (5.6) |
| 1,1,1-Trichloroethane | 34800 | 438000 | ND (2.0) | ND (0.25) | ND (2.0) |
| 1,1,2-Trichloroethane | 1.39 | 17.5 | *ND (3.3)* | ND (0.41) | *ND (3.3)* |
| Trichloroethylene; Trichloroethene; TCE | 13.9 | 175 | 6.0 J | *750* | *53000* |
| Trichlorofluoromethane | 4870 | 61300 | 6.3 J | 2.1 J | 4.5 J |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) | 209000 | 2630000 | 1300 | 39 L-05 | 200 |
| 1,2,4-Trimethylbenzene | 48.7 | 613 | *53* | 19 | 31 |
| 1,3,5-Trimethylbenzene | ~ | ~ | 8.3 J | 3.5 | 4.5 J |
| Vinyl Acetate | 1390 | 17500 | ND (3.6) | ND (0.45) | ND (3.6) |
| Vinyl chloride; Chloroethene | 55.9 | 2790 | ND (2.2) | ND (0.27) | ND (2.2) |
| Xylene, m&p | 695 | 8760 | 46 | 17 | 36 |
| Xylene, o- | 695 | 8760 | 17 | 6.7 | 13 |

NOTES:
1. ND = Not detected above the lab reporting limits shown in parenthesis.
2. NT = Not tested.
3. ~ = No IHSB Residential or Non-Residential screening limits limits.
6. Yellow Shaded values exceed the IHSB Residential Soil-Gas Screening Limits.
7. Red Shaded values exceed the IHSB Non-Residential Soil-Gas Screening Limits.
8. J = Estimated Value
9. B = Analyte found in the associated blank as well as the sample.

# APPENDIX C

## November 2014 Groundwater Monitoring Analytical Results – AMEC 2015

**Table 2 (Page 1 of 2)**
**Fourth Quarter Ground-Water Sampling Event - 2014**
**Laboratory Analytical Results**
**CORNING/AVX Facility**
**Raleigh, North Carolina**
**AMEC Project No. 6550-12-0032**

| Chlorinated Organic Compounds | Sample Location | | | | | | | | | | | | | | NC GROUNDWATER STANDARD (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MW-1A | MW-1B | MW-2 | MW-3A | MW-3B | MW-3C | MW-4A | MW-4B | MW-5A | MW-5B | MW-6A | MW-6B | MW-7B | MW-8B | |
| **Bromodichloromethane** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.0006** |
| **Chloroform** | 0.041 | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.07** |
| **1,1-Dichloroethene** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.007** |
| **1,1-Dichloroethane** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.006** |
| **cis-1,2-Dichloroethene** | **0.087** | BDL | 0.0092 | 0.052 | 0.003 | BDL | BDL | BDL | 0.0088 | 0.0044 | BDL | BDL | BDL | BDL | **0.07** |
| **trans-1,2-Dichloroethene** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.1** |
| **Methylene chloride** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.005** |
| **Naphthalene** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.006** |
| **Tetrachloroethene** | BDL | BDL | **0.0034** | **0.025** | **0.022** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.0007** |
| **1,2-Dichloropropane** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.0006** |
| **1,1,2-Trichloroethane** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.0006** |
| **Trichloroethene** | **0.42** | BDL | **0.034** | **2.400** | **0.0065** | **0.90** | **0.0038** | **1.80** | **0.046** | **0.25** | **0.005** | **0.52** | 0.0015 | BDL | **0.003** |
| **1,1,2-Trichlorotrifluoroethane** | BDL | BDL | 0.0014 | 0.058 | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **200** |
| **1,2,4-Trimethylbenzene** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.4** |
| **1,1,1-Trichloroethane** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.2** |
| **Trichlorofluoromethane** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **2** |
| **Vinyl Chloride** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **0.00003** |
| **Total Concentration** | **0.548** | **0.00** | **0.048** | **2.535** | **0.0315** | **0.90** | **0.0038** | **1.80** | **0.0548** | **0.2544** | **0.005** | **0.52** | **0.0015** | **0.00** | |
| **Nonchlorinated Organic Compounds** | | | | | | | | | | | | | | | |
| **Acetone** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **6** |
| **Ethylbenzene** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **0.6** |
| **2-Butanone (MEK)** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **4** |
| **Isopropylbenzene** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **0.07** |
| **Toluene** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **0.6** |
| **Xylenes(total)** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **0.5** |
| **Benzene** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | **0.001** |
| **Total Concentration** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | |

**NOTES: 1) Samples collected 11/25/14**
**2) Concentrations are shown in milligrams per liter (mg/L) or parts per million (ppm).**
**3) NS = "Narrative Standard" - standard is the detection limit of the analytical method.**
**4) NC GROUNDWATER STANDARD - Title15A NCAC Subchapter 2L Ground-Water Standards (Amended on 4/1/2013).**
**5) BDL = Below Detection Limits at quantitation limit shown on Lab Data (Appendix B)**
**6) Numbers in Bold print denotes that result exceeds the NC Ground-water standard for that constituent.**
**7) Duplicate was collected at MW-11B.**
**8) ND = Non Detect**

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Checked by: WBM 12/12/14

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**Table 2 (Page 2 of 2)**
**Fourth Quarter Ground-Water Sampling Event - 2014**
**Laboratory Analytical Results**
**CORNING/AVX Facility**
**Raleigh, North Carolina**
**AMEC Project No. 6550-12-0032**

| Chlorinated Organic Compounds | Sample Location | | | | | | | | | | | | | NC GROUNDWATER STANDARD (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MW-9B | MW-10A | MW-10B | MW-11A | MW-11B | RW-12B | MW-13A | MW-13B | Prestripper | Poststripper | Upstream | Downstream | Duplicate | |
| Bromodichloromethane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.0006 |
| Chloroform | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.07 |
| 1,1-Dichloroethene | BDL | BDL | 0.0013 | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.007 |
| 1,1-Dichloroethane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.006 |
| cis-1,2-Dichloroethene | 0.0048 | BDL | 0.004 | BDL | BDL | **0.071** | NS | NS | 0.035 | 0.035 | BDL | 0.0022 | 0.012 | 0.07 |
| trans-1,2-Dichloroethene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.1 |
| Methylene chloride | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.005 |
| Naphthalene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.006 |
| Tetrachloroethene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | **0.0037** | 0.0007 |
| 1,2-Dichloropropane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.0006 |
| 1,1,2-Trichloroethane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.0006 |
| Trichloroethene | **0.032** | **0.017** | **0.018** | BDL | BDL | **0.37** | NS | NS | **0.66** | **0.70** | BDL | **0.05** | **0.04** | 0.003 |
| 1,1,2-Trichlorotrifluoroethane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | 0.0016 | 200 |
| 1,2,4-Trimethylbenzene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.4 |
| 1,1,1-Trichloroethane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.2 |
| Trichlorofluoromethane | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 2 |
| Vinyl Chloride | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | BDL | BDL | BDL | BDL | BDL | 0.00003 |
| Total Concentration | **0.0368** | **0.017** | **0.0233** | **0** | **0** | **0.441** | **0** | **0** | **0.695** | **0.735** | **0** | **0.0522** | **0.06** | |
| Nonchlorinated Organic Compounds | | | | | | | | | | | | | | |
| Acetone | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 6 |
| Ethylbenzene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 0.6 |
| 2-Butanone (MEK) | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 4 |
| Isopropylbenzene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 0.07 |
| Toluene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 0.6 |
| Xylenes(total) | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 0.5 |
| Benzene | BDL | BDL | BDL | BDL | BDL | BDL | NS | NS | NA | NA | BDL | BDL | BDL | 0.001 |
| Total Concentration | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | |

**NOTES:** 1) Samples collected 11/25/14
2) Concentrations are shown in milligrams per liter (mg/L) or parts per million (ppm).
3) NS = "Narrative Standard" - standard is the detection limit of the analytical method or "Not Sampled".
4) NC GROUNDWATER STANDARD - Title15A NCAC Subchapter 2L Ground-Water Standards (Amended on 4/1/2013).
5) BDL = Below Detection Limits at quantitation limit shown on Lab Data (Appendix B)
6) Numbers in Bold print denotes that result exceeds the NC Ground-water standard (2L) for that constituent.
7) Duplicate was collected at MW-2.
* 8) The surface water standard for Class C, Nutrient Sensitive Waters (NSW) is 30 µg/L for TCE according to Human Health Standards.
9) ND = Non Detect
10) Monitoring wells MW-13A and MW-13B were installed in August 2013
11) Pre-Stripper and Post-Stripper samples were analyzed by methods 601 / 602
12) NA = Not Analyzed

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# APPENDIX D

## SOP428199 – Soil Gas Sampling using Single or Nested Ports

ARCADIS
Infrastructure, environment, facilities

Imagine the result

# Soil Gas Sampling Using Single or Nested Ports

SOP # 428199

Rev. #: 4

Rev Date: July 9, 2010

**Approval Signatures**

Prepared by: _____ Date: 07/09/2010
Mitch Wacksman and Andrew Gutherz

Approved by: _____ Date: 07/09/2010
Christopher Lutes and Nadine Weinberg

## I. Scope and Application

This document describes the procedures for installing semi-permanent or permanent single or nested soil-gas ports and collecting soil-gas samples. Nested soil-gas ports allow for the generation of discrete data as a function of depth and time. Samples are collected for the analysis of volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 (TO-15). Method TO-15 uses a 1-liter, 3-liter of 6-liter SUMMA® passivated stainless steel canister. An evacuated SUMMA canister (less than 28 inches of mercury [Hg]) will provide a recoverable whole-gas sample of approximately 5 liters when allowed to fill to a vacuum of 6 inches of Hg. The whole-air sample is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GS/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv). Optionally, the whole air sample can also be analyzed for permanent gasses such as oxygen and carbon dioxide.

The following sections list the necessary equipment and provide detailed instructions for the installation of semi-permanent or permanent single or nested soil-gas ports (using direct-push technology or a hollow stem auger) and the collection of soil-gas samples for VOC analysis.

## II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training. Site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), may be appropriate at some sites. ARCADIS field sampling personnel will be well versed in the relevant standard operating procedures (SOPs) and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading soil-gas sample collection activities must have previous soil-gas sampling experience.

## III. Health and Safety Considerations

All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. For vapor port installation, drilling with a direct-push drilling rig

or hollow stem auger rig should be done only by personnel with prior experience using such of equipment.

## IV. Equipment List

The equipment required to install single or nested soil vapor ports is presented below:

- Appropriate personal protective equipment (PPE ; as required by the HASP and JLA);
- Appropriate drill rig to reach necessary sample depth (hollow stem auger, direct-push rig, etc)
    - Hollow stem auger rig with interconnecting augers. The inner diameter of typical augers ranges from 2.25-inches to 7.75-inches; the auger size should be chosen should be large enough to accommodate the number of nested ports that will be installed inside the boring.
    - Direct-push rig (e.g., -Geoprobe) equipped with interconnecting 4-foot lengths of steel drive rods (2.25-inch-diameter, or 3.25-inch diameter depending on the number of ports to be installed).
- 1/4-inch outside diameter (OD) x 1/8-inch inside diameter (ID) tubing (Teflon, Teflon lined, or nylon). Note that Nylaflow tubing has a somewhat higher background level of BTEX and much poorer recovery of trichlorobenzene and naphthalene then Teflon, so it should not be used on site where these compounds are a concern (Hayes, 2006)
- Stainless steel sample screens with sacrificial point (one per sample depth to weight sample screen, available from Geoprobe). Typically 6” long for sized for 1/4-inch OD tubing.
- Stainless steel, or Teflon ball valve or needle valve (one per sample depth to match sample tubing) for sample line termination.
- Commercially available clean sand filter pack or glass beads having a grain size larger than 0.0057-inch (pore diameter of screen)

- Granular and powdered bentonite (Benseal®, Volclay® Crumbles, or equivalent)
- Down hole measuring device
- Distilled or Deionized water for hydration of bentonite
- Plastic or aluminum tags for permanently labeling port with sample depth, and port identification number. It is no recommended to write on or affix adhesive tape to tubing as these methods fail over time.
- Well cover for permanent installation, This should be a traffic rated road box for exterior installations or an appropriate clean-out cover for interior installations.
- Photoionization Detector (PID) (with a lamp of 11.7 eV).

The equipment required for soil-gas sample collection from single or nested ports is presented below:

- 1,3, or 6 – liter stainless steel SUMMA® canisters (order at least one extra, if feasible) (batch certified canisters or individual certified canisters as required by the project)
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g., 30 minutes, 8 hours, 24 hours) or flow rate (e.g., 200 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible). Flow rate should be selected based on expected soil type (see below)
- Decontaminated stainless steel1/4-inch Swagelok (or equivalent) fittings (e.g., nuts, ferrules and backers)
- Decontaminated stainless steel Swagelok or comparable “T” fitting and needle valve for isolation of purge pump.
- Stainless steel or brass “T” fitting (if collecting duplicate [i.e., split] samples). Swage-lok or comparable

- Portable vacuum pump capable of producing very low flow rates (e.g., 100 to 200 mL/min) with vacuum gauge. Purging flow rate should also be selected based on expected soil type (see below).
- Rotameter or an electric flow sensor if vacuum pump does not have an accurate flow gauge (Bios DryCal or equivalent).
- Tracer gas testing supplies if applicable (refer to tracer SOP)
- Photoionization Detector (PID) (with a lamp of 11.7 eV)
- Appropriate-sized open-end wrench (typically 9/16-inch, 1/2-inch, and 3/4-inch)
- Down hole measuring device (e.g., water level probe, tape measure)
- Portable weather meter, if appropriate
- Chain-of-custody (COC) forms
- Sample collection logs (attached)
- Field Book

## V. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a single or nested soil-gas sample.

- When drilling to install sampling ports , be mindful of utilities that may be in the area. Follow ARCADIS utility location procedure. If the driller is concerned about a particular location, consult the project manager about moving it to another location. Do not hesitate to use Stop Work Authority; if something doesn't seem right stop and remedy the situation.
- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 3-7–inches Hg) remains in the canister when sample collection is terminated. Do not let sample canister reach atmospheric pressure (e.g., 0-inches Hg).

- Care should be taken to ensure that nested ports are installed at the target sample depths within the sand filer pack.. Sampling personnel should work closely with the driller to accomplish this.

- When introducing granular bentonite to the boring, the material should be introduced slowly and hydrated properly. Consult the bentonite manufacturer's instructions on the bag to determine the proper amount of to be used. When hydrated properly bentonite forms a thick clay mass that remains moist. The hydration step is crucial in the installation process and if not done properly the integrity of the bentonite seal can be compromised.

- Using prehydrated bentonite is best and should be discussed with drilling subcontractor.

- The purge flow rate of 100 ml/min should be suitable for a variety of silt and sand conditions but will not be achievable in some clays without excessive vacuum. Thus lower flow rates may be necessary in clay. A low vacuum (<10" of mercury) should be maintained. Record the measured flow rate and vacuum pressure during sample collection.

  The cutoff value for vacuum differs in the literature from 10" of water column (ITRC 2007) to 136" of water column or 10" of mercury (http://www.dtsc.ca.gov/lawsregspolicies/policies/SiteCleanup/upload/SMBR_ADV_activesoilgasinvst.pdf). A detailed discussion of the achievable flow rates in various permeability materials can be found in Nicholson 2007. Related issues of contaminant partitioning are summarized in ASTM D5314-92. Passive sampling approaches can be considered as an alternative for clay soils although most passive methods for soil gas do not yield a quantitative concentration in soil gas.

- It is important to record the canister pressure, start and stop times and ID on a proper field sampling form. You should observe and record the

time/pressure at a mid-point in the sample duration. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from labs have offset errors, or they stick.

- When sampling carefully consider elevation. If your site is over 2,000' above sea level or the difference in elevation between your site and your lab is more than 2,000' then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in them. http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped a two or three days before the sampling date so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Soil-gas sampling should not proceed within 5 days following a significant rain event (1/2-inch of rainfall or more). Exceptions to this requirement may be appropriate depending on site climatic conditions, soil gas point depth and soil drainage characteristics. However since this requirement is frequently contained in regulatory documents, any exception to this requirement must be discussed with client and/or regulatory representatives. ITRC (2007) discussed the conditions when this requirement may not be necessary: "*Infiltration from rainfall can potentially impact soil gas concentrations by displacing the soil gas, dissolving VOCs, and by creating a "cap" above the soil gas. In many settings, infiltration from large storms penetrates into only the uppermost vadose zone. In general, soil gas samples collected at depths greater than about 3–5 feet bgs or under foundations or areas with surface cover are unlikely to be significantly affected. Soil gas samples collected closer to the surface (<3 feet) with no surface cover may be affected. If the moisture has penetrated to the*

*sampling zone, it typically can be recognized by difficulty in collecting soil gas samples. "*

## VI. Procedure

### Single or Nested Soil-Gas Monitoring Point Installation

The procedure used to install semi-permanent or permanent single or nested soil-gas ports will vary based upon the method of boring installation. In most situations a temporary well casing well need to be installed to keep the down hole formation from collapsing during port installation. The following steps will detail installing nested soil-gas ports through a temporary well casing.

If the nested ports will be installed at shallow depths, or the formation is thought to be stable enough to not collapse, a temporary well casing may not be necessary to facilitate the installation of the sample ports. Either way, the steps for installing the sample ports are nearly identical. These following steps should be discussed with the drilling subcontractor and altered based on the methods chosen for a given project.

1. Advance boring to bottom of deepest sampling interval and install a temporary well casing. Care should be taken to ensure that the terminal depth of the boring does not reach groundwater or the capillary fringe. Soil-gas probes should not be installed in groundwater or the capillary fringe. Moisture conditions and/or other observations (such as depth to water in nearby monitoring wells) should be recorded on the soil-gas collection log, as indicated.

2. Cut a length of 1/4-inch tubing slightly longer (e.g., 4 to 5 feet) than the collection depth. Attach a stainless steel sample screen and sacrificial point to the tubing and lower the screen and attached tubing through the boring.

3. Assure that the sample screen has reached the bottom of the boring and record this depth.

4. Begin simultaneously filling in the area around the sample screen with sand filter pack and retracting the temporary well casing. The casing should be lowered back down onto the sand every few inches to compact the sand around the screen. Sand should be introduced 3-inches below the screen, to cover the 6-inch sample screen and extend 3-inches inches above the screen for a total of 12 inches of sand. Closely monitor the amount of sand added to the borehole with a tape measure or water level probe.

5. With the proper sand pack in place begin slowly introducing 6-inches of dry granular bentonite into the boring. This dry Bentonite will prevent water from entering the sand filter pack during hydration.

6. A slurry of hydrated bentonite should be placed above the dry granular bentonite to the next sample depth (for nested ports) or to the ground surface (for single ports).

7. Properly label the sample tubing with a permanent label to designate the sample number and screen depth.

8. Affix a Swagelok fitting and valve to the end of the tubing.

9. Add an inch or two of dry granular Bentonite over the bentonite slurry prior to installing the subsequent sand filter pack and screen.

10. Repeat steps 2-8 until all the sample depths are installed.

11. With all semi-permanent or permanent single or nested ports installed and labeled, a well cover may be installed.

    a. For permanent installations, the well cover should be rated for whatever type of traffic it may encounter in the future. For interior installations a brass clean-out cover available from a plumbing supply store may provide adequate protection. For exterior installations in high traffic areas a heavy duty groundwater well cover may be appropriate.

    b. For a semi-permanent installation, a well cover is generally not necessary as the tubing will be removed within several days.

12. All soil-gas points should be allowed to sit and equilibrate for a minimum of 24-hours before proceeding to soil-gas sample collection.

**Soil-Gas Sample Collection**

The following steps should be used to collect a soil-gas sample from each of the single or nested probes installed using the above procedure.

1. Record the following information on the sample log, if appropriate (contact the local airport or other suitable information source [e.g., site-specific measurements, weatherunderground.com] to obtain the information):

    a. wind speed and direction;

    b. ambient temperature;

    c. barometric pressure; and

    d. relative humidity.

2. Assemble the sample train by removing the cap from the SUMMA canister and connecting the Swagelok T-fitting to the can using a short length of 1/4-inch OD Teflon tubing. The flow controller with in-line particulate filter and vacuum gauge is then attached to the T-fitting. The Swagelok (or similar) two-way valve is connected to the free end of the T-fitting using a short length of ¼-inch OD Teflon tubing (precleaned stainless steel tubing could also be used)..

3. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two SUMMA canisters using stainless steel Swagelok duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample T-fitting provided by the laboratory.

4. Attach Teflon sample tubing to the flow controller using Swagelok fittings.

5. Remove the flush Swagelok cap from the sample port and install a Swagelok nut, ferrules, and sample tubing into the sub-slab port.

6. Connect the two-way valve and the portable purge pump using a length of Teflon sample tubing.

7. Record on the sample log and COC form the flow controller number with the appropriate SUMMA® canister number.

    a. Perform a leak-down-test by replacing the nut which secures sample tubing with the cap from the canister or closing the valve on the sample port. This will create a closed system. Open the canister

valve and quickly close it; the vacuum should increase approaching 30" Hg. If there are no leaks in the system this vacuum should be held. If vacuum holds proceed with sample collection; if not attempt to rectify the situation by tightening fittings.

8. The seal around the soil-gas sampling port and the numerous connections comprising the sampling train will be evaluated for leaks using helium as a tracer gas. The helium tracer gas will be administered according to the methods established in the appropriate guidance documents and SOP: Administering Tracer Gas.

9. Open the two-way valve and purge the soil-gas sampling port and tubing with the portable sampling pump. Purge approximately three volumes of air from the soil-gas sampling port and sampling line using a flow rate of 200 mL/min. Purge volume is calculated by the following equation "purge volume = 3 x Pi x inner radius of tubing$^2$ x length of tubing. Purge air should be vented away from personnel and sampling equipment, a length of tubing or Tedlar bag can be used for this purpose. Measure organic vapor levels and tracer gas within the Tedlar bag, as appropriate.

10. Close the two-way valve to isolate the purge pump.

11. Open the SUMMA® canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.

If the initial vacuum pressure registers less than -25 inches of Hg, then the SUMMA® canister is not appropriate for use and another canister should be used.

12. Take a photograph of the SUMMA® canister and surrounding area unless prohibited by the property owner.

13. Check the SUMMA canister pressure approximately half way through the sample duration and note progress on sample logs.

14. Steps 2-10 should be repeated for each of the nested soil-gas ports; samples can be collected concurrently.

**Termination of Sample Collection**

1. Arrive at the SUMMA® canister location at least 1-2 hours prior to the end of the required sampling interval (e.g., 8, 24-hours)..

2. Record the final vacuum pressure. Stop collecting the sample by closing the SUMMA® canister valves. The canister should have a minimum amount of vacuum (approximately 6 inches of Hg or slightly greater).

3. Record the date and time of valve closing on the sample log and COC form.

4. Close the valve on the nested soil-gas sample tubing or replace Swagelok cap.

5. Once all the nested samples have been collected, be sure the well cover (if applicable) is properly re-installed and secured.

6. Remove the particulate filters and flow controllers from the SUMMA® canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.

7. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canisters should <u>not</u> be preserved with ice or refrigeration during shipment.

8. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

9. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via overnight carrier (e.g., Federal Express) for analysis.

**VII. Soil-Gas Monitoring Point Abandonment**

If the single or nested soil-gas ports were installed in a semi-permanent manner, and the soil-gas samples have been collected, the soil-gas monitoring points will be abandoned by pulling up the sample tubing. Since the boring is filled with bentonite and sand, no additional abandonment steps are necessary. Ensure that the boring location and surrounding area are returned to as close to their original appearance as possible.

## VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project workplan.

## IX. Data Recording and Management

Measurements will be recorded on the sample log at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure), canister serial number, flow controller serial number, initial vacuum reading, and final pressure reading. Field sampling logs and COC records will be transmitted to the Project Manager.

## X. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Generally, duplicates are taken of 10% of samples, but project specific requirements should take precedence.

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs). A trip blank sample will accompany each shipment of soil-gas samples to the laboratory for analysis. Trip blanks assess potential sample contamination resulting from the transportation and storing of samples.

Duplicate soil gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the soil-gas probe simultaneously.

## XI. References

ASTM – “Standard Guide for Soil Gas Monitoring in the Vadose Zone”, D5314-92.

ITRC “Vapor Intrusion Pathway: A Practical Guide”, January 2007, Appendix F: “regulators Checklist for Reviewing Soil Gas Data”

New York State Department of Health (NYSDOH). 2005. DRAFT "Guidance for Evaluating Soil Vapor Intrusion in the State of New York" February 23, 2005.

Nicholson, P, D. Bertrand and T. McAlary. "Soil Gas Sampling in Low-Permeability Materials" Presented at AWMA Specialty Conference on Vapor Intrusion, Providence RI, Sept 200

Hayes, H. C., D. J. Benton and N. Khan "Impact of Sampling Media on Soil Gas Measurements" Presented with short paper at AWMA Vapor Intrusion Conference, January2006, Philadelphia, PA.

# Sub-slab Soil Vapor Sample Collection Log

| | | | |
|---|---|---|---|
| | | **Sample ID:** | |
| **Client:** | | **Boring Equipment:** | |
| **Project:** | | **Sealant:** | |
| **Location:** | | **Tubing Information:** | |
| **Project #:** | | **Miscellaneous Equipment:** | |
| **Samplers:** | | **Subcontractor:** | |
| ` | | **Equipment:** | |
| **Sampling Depth:** | | **Moisture Content of Sampling Zone):** | |
| **Time and Date of Installation:** | | **Approximate Purge Volume:** | |

**Instrument Readings:**

| Date | Time | Canister Vacuum (a) (inches of Hg) | Temperature (°F) | Relative Humidity (%) | Air Speed (mph) | Barometric Pressure (inches of Hg) | PID (ppb) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

(a) Record canister information at a minimum at the beginning and end of sampling

**SUMMA Canister Information:**

| | |
|---|---|
| **Size (circle one):** | **1 L** **6 L** |
| **Canister ID:** | |
| **Flow Controller ID:** | |
| **Notes:** | |

**Tracer Test Information (if applicable):**

| | |
|---|---|
| **Initial Helium Shroud:** | |
| **Final Helium Shroud:** | |
| **Tracer Test Passed:** | **Yes** **No** |
| **Notes:** | |

**General Observations/Notes:**

| |
|---|
| |
| |
| |

**Approximating One-Well Volume (for purging):**

When using 1¼-inch "Dummy Point" and a 6-inch sampling interval, the sampling space will have a volume of approximately 150 mL. Each foot of ¼-inch tubing will have a volume of approximately 10 mL.

# APPENDIX E

## SOP416199 – Tracer Gas

ARCADIS
Infrastructure, environment, facilities

Imagine the result

# Administering Helium Tracer Gas for Leak Checks of Soil Gas or Sub-slab Sampling Points

SOP #416199

Rev. #: 3

Rev Date: July 7, 2010

**Approval Signatures**

Prepared by: _____ Date: 07/07/2010
Mitch Wacksman and Andrew Gutherz

Approved by: _____ Date: 07/07/2010
Christopher Lutes and Nadine Weinberg

## I. Scope and Application

When collecting subsurface vapor samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control method to verify the integrity of the vapor port seal and the numerous connections comprising the sample train. Without the use of a tracer, verification that a soil vapor sample has not been diluted by ambient or indoor air is difficult.

This standard operating procedure (SOP) focuses on using helium as a tracer gas. However, depending on the nature of the contaminants of concern, other compounds can be used as a tracer including sulfur hexafluoride (SF6), butane and propane (or other gases). In all cases, the protocol for using a tracer gas is consistent and includes the following basic steps: (1) enrich the atmosphere in the immediate vicinity of the sample port where ambient air could enter the sampling train during sampling with the tracer gas; and (2) measure a vapor sample from the sample tubing for the presence of elevated concentrations (> 10%) of the tracer. A plastic pail, bucket, garbage can or even a plastic bag can serve to keep the tracer gas in contact with the port during the testing.

There are two basic approaches to testing for the tracer gas:

1. Include the tracer gas in the list of target analytes reported by the laboratory; and/or

2. Use a portable monitoring device to analyze a sample of soil vapor for the tracer prior to sampling for the compounds of concern. (Note that tracer gas samples can be collected via syringe, Tedlar bag, etc. They need not be collected in SUMMA® canisters or minicans.)

This SOP focuses on monitoring helium using a portable sampling device, although helium can also be analyzed by the laboratory along with other volatile organic compounds (VOCs). Real-time tracer sampling is generally preferred as the results can be used to confirm the integrity of the port seals prior to formal sample collection.

During the initial stages of a subsurface vapor sampling program, tracer gas samples should be collected at each of the sampling points. If the results of the initial samples indicate that the port seals are adequate, the Project Manager can consider reducing the number of locations at which tracer gas samples are used in future monitoring rounds. At a minimum, at least 5% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil vapor points as part of a long-term monitoring program, the port should be tested prior to the first sampling event. Tracer gas testing of subsequent sampling events may often be reduced or eliminated unless conditions have changed at the site. Soil gas port integrity should certainly be

rechecked with Tracer gas if land clearing/grading activities, freeze thaw cycles, or soil dessication may have occurred. Points should also be rechecked if more than 2 years have elapsed since the last check of that port.

## II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the tracer gas testing must have previous experience conducting similar tests.

## III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job safety analysis (JSA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. Field staff should review the attachment on safely handling compressed gas cylinders prior to commencing field work.

## IV. Equipment List

The equipment required to conduct a helium tracer gas test is presented below:

- Appropriate PPE for site (as required by the Health and Safety Plan)
- Helium (laboratory grade)
- Regulator for helium tank
- Shroud (plastic bucket, garbage can, etc)
    - The size of the shroud should be sufficient to fit over the sample port. It is worth noting that using the smallest shroud possible will miminze the volume of helium needed; this may be important when projects require a large number of helium tracer tests.
    - The shroud will need to have three small holes in it. These holes will include one on the top (to accommodate the sample tubing), and two

on the side (one for the helium detector probe, and one for the helium line).

  - The shroud should ideally enclose the sample port and as much as possible of the sampling train.

- Helium detector capable of measuring from 1 - 100% (Dielectric MGD-2002, Mark Model 9522, or equivalent)

- Tedlar bags

- Seal material for shroud (rubber gasket, modeling clay, bentonite, etc) to keep helium levels in shroud high in windy conditions. Although the sealing material is not in direct contact with the sample if leakage does not occur, sealing materials with high levels of VOC emissions should be avoided, since they could contaminate a sample if a leak occurs.

- Sample logs

- Field notebook

## V. Cautions

Helium is an asphyxiant! Be cautious with its use indoors! Never release large volumes of helium within a closed room!

Compressed gas cylinders should be handled with caution; see attachment on the use and storage of compressed gasses before beginning field work.

Care should be taken not to pressurize the shroud while introducing helium. If the shroud is completely air tight and the helium is introduced quickly, the shroud can be over-pressurized and helium can be pushed into the ground. Provide a relief valve or small gap where the helium can escape.

Because minor leakage around the port seal should not materially affect the usability of the soil vapor sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (> 10%) of tracer gas are observed in a sample, the port seal should be enhanced and fittings within the sampling train should be should be checked and/or tightened to reduce the infiltration of ambient air and the tracer test readministered. If the problem cannot be rectified, a new sample point should be installed or an alternate sampling train used.

## VI. Procedure

The procedure used to conduct the helium tracer test should be specific to the shroud being used and the methods of vapor point installation. The helium tracer test can be conducted when using temporary or permanent sampling points and inside or outside a facility. When using the tracer gas within indoor areas you must provide adequate ventilation as helium is an asphyxiant.

1. Attach Teflon or nylon (Nylaflow) sample tubing to the sample point. This can be accomplished utilizing a number of different methods depending on the sample install (i.e., most typically Swage-Lok brand compression fittings, but some quick release fittings could also be used etc.).

2. Place the shroud over the sample point and tubing.

3. Pull the tubing through hole in top of shroud. Seal opening at top of shroud with modeling clay.

4. Place weight on top of shroud to help maintain a good seal with the ground.

5. Insert helium tubing and helium detector probe into side of shroud. Seal both with modeling clay to prevent leaks.

6. Fill shroud with helium. Fill shroud slowly, allowing atmospheric air to escape either by leaving a gap where the shroud meets the ground surface or by providing a release value on the side of the shroud.

7. Use the helium detector to monitor helium concentration within the shroud from the lowest hole drilled in the shroud (bottom of the shroud nearest where the sample tubing intersects the ground). Helium should be added until the environment inside the shroud has > 60% helium.

8. Purge the sample point through the sample tubing into a Tedlar bag using a hand held sampling pump. The purge rate should at least match the sample collection rate but not exceed 100 ml/min. Test the air in the Tedlar bag for helium using portable helium detector. If the point is free of leaks there should be very low helium in the purge air from the soil. The natural concentration of helium in the atmosphere is 0.00052% by volume and there are few if any natural sources of helium to soil gas.

9. If > 10% helium is noted in purge air, add more clay or other material to the seal the sample port and repeat the testing procedure. If the seal cannot be fixed, re-install sample point.

10. Monitor and record helium level in shroud before, during and after tracer test.

11. Monitor and record helium level in purge exhaust.

12. At successful completion of tracer test and sample point purging, the soil vapor sample can be collected (if the helium shroud must be removed prior to sample collection be mindful not disturb the sample tubing and any established seals).

## VII. Data Recording and Management

Measurements will be recorded on the sample logs at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location, and the helium concentrations in both the shroud and the purge air before, during, and after tracer testing. Any problems encountered should also be recorded in the field notes.

## ATTACHMENT: Compressed Gases—Use and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

**Handling**

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered with.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 °C (122 °F). Some rupture devices on cylinders will release at about 65 °C (149 °F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.

- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.
- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

**Storage**

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

## *Special Precautions*

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.
- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

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