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Report of Findings
Building 310 VOC Source Investigation and Implemented Measures
IBM East Fishkill Facility
Hopewell Junction, New York

Prepared for
IBM Corporation

East Fishkill, New York

Prepared by
Sanborn, Head Engineering P.C.

File 2999.00
April 2010

Hudson Valley Research Park
2070 Route 52
Hopewell Junction, NY 12533-6531
D.E. Speed Zip 65A

April 7, 2010

Mr. Alex G. Czuhanich
New York State Department of Environmental Conservation
Division of Solid and Hazardous Materials
625 Broadway
Albany, NY 12233-7258

Re: Report of Findings
Building 310 VOC Source Investigation and Implemented Measures
RFI Work Plan Implementation
IBM East Fishkill Facility, Hopewell Junction, New York
EPA ID No. NYD000707901

Dear Mr. Czuhanich:

The enclosed report presents the findings relative to volatile organic compound (VOC) source investigation and measures implemented within Building 310 at the IBM East Fishkill facility. IBM conducted this work between October 2008 and December 2009. Progress updates and preliminary data associated with this work have been communicated to the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH) (collectively, the Agencies) through regular correspondence and meetings.

If you wish to further discuss this report or have questions, please contact me at (845) 892-3176.

Sincerely,

David E. Speed, Ph.D.
Systems and Technology Group
International Business Machines Corporation

cc: H. Wilkie (NYSDEC)
E. Dassatti (NYSDEC)
N. Walz (NYSDOH)
G. Litwin (NYSDOH)
S. Hawkins (IBM)

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April 7, 2010
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David E. Speed, Ph.D.
IBM Corporation
Hudson Valley Research Park
2070 Route 52, Zip 65A
Hopewell Junction, New York 12533-6531

Re: Report of Findings
Building 310 VOC Source Investigation and Implemented Measures
RFI Work Plan Implementation
IBM East Fishkill Facility, Hopewell Junction, New York

Dear Dr. Speed:

The attached document presents the report of findings relative to the Building 310 VOC source investigation and implemented measures at the IBM East Fishkill facility. The work and this report were implemented in a manner consistent with the objectives and procedures described in IBM's RCRA Facility Investigation (RFI) Work Plan[1].

Thank you for the opportunity to be of service to IBM. Please contact us if we can be of further assistance.

Very truly yours,
SANBORN, HEAD ENGINEERING, PC

David Shea, PE
Sr. Project Director

Daniel B. Carr, PE, PG
Vice President/Principal

Attach: Report of Findings – Building 310 VOC Source Investigation and Implemented Measures

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[1] *Work Plan, RCRA Facility Investigation (RFI), VOC Source Assessment, IBM East Fishkill Facility, Hopewell Junction, New York*, IBM Corporation and Sanborn, Head Engineering P.C., June 15, 2009.

Report of Findings
Building 310 VOC Source Investigation and Implemented Measures
IBM East Fishkill Facility
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APPENDICES

1.0 INTRODUCTION

This report presents the findings of investigations, testing, and actions taken relative to indoor air conditions in Building 310 at the IBM East Fishkill facility (the Site). A Site locus plan is provided as Figure 1, and the Building 310 location on the Site is shown on Figure 2.

This work was conducted in a manner consistent with the objectives and procedures described in IBM's RCRA Facility Investigation (RFI) Work Plan (the Work Plan)[1]. Building 310 was identified in the Work Plan as a building targeted for an investigation of possible sources of anomalous indoor air presence of volatile organic compounds (VOCs). Tetrachloroethene (also known as perchloroethene or PCE) was the principal VOC detected in past indoor air samples.

Sanborn, Head Engineering P.C. (SHPC) and IBM personnel conducted the source investigation work beginning in October 2008 through December 2009. Progress updates and preliminary data associated with this work have been communicated to the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH) (collectively, the Agencies) through regular correspondence and meetings. The work and this report are subject to the standard limitations for this type of work, as outlined in Appendix A.

1.1 Report Organization

This report is organized into five sections as described below:

Section 1 presents a general introduction, including objectives, scope, and an overview of the work.

Section 2 provides background information on Building 310 and an overview of heating, ventilation, and air conditioning (HVAC) system operations.

Section 3 presents a summary of the VOC source assessment activities, including the findings of initial screening, indoor air sampling, subslab sampling and pressure monitoring, subslab vapor extraction testing, and other investigation activities.

Section 4 describes the actions taken in Building 310 and the results of follow-up indoor air sampling.

Section 5 presents the conclusions of the work and this report.

1.2 Objectives and Scope

The objectives of this work were to identify the source(s) of anomalous indoor air conditions in Building 310 and to take steps to mitigate the conditions. As outlined in the Work Plan, the term

[1] *Work Plan, RCRA Facility Investigation (RFI), VOC Source Assessment, IBM East Fishkill Facility, Hopewell Junction, New York*, IBM Corporation and Sanborn, Head Engineering P.C., June 15, 2009.

"anomalous" is intended to connote indoor air conditions that cannot be explained by present storage and/or occupational uses of VOC-containing solvents or ambient (outdoor) air quality.

To meet these objectives, the work included:

- Review of historical records and reports pertaining to virgin and waste solvent use and infrastructure, solid waste management unit (SWMU) locations, and previous RFI reports and corrective action status reports related to subsurface VOC presence beneath and proximate to Building 310;

- Reconnaissance of Building 310, including an initial screening for VOC presence in indoor air using hand-held instruments;

- Indoor air sampling using various sampling and analytical methods;

- Assessment of potential ambient outdoor air conditions, including outdoor air sampling;

- Review, testing, and confirmation of HVAC system operations;

- Subslab vapor sampling, differential pressure monitoring, and subslab vapor extraction testing; and

- Implementation of response measures focused on modifications and adjustments to certain HVAC systems.

The above work was conducted over the period from October 2008 to December 2009.

1.3 Overview of Findings

The investigation revealed that higher VOC concentrations in indoor air occurred in particular areas of Building 310 where higher VOC concentrations in subslab vapor were present and where air exchange rates were relatively low. In general, these areas of the building are storage areas and former manufacturing areas that are not regularly occupied. The room air pressure was also found to be near neutral, or slightly lower than air pressure beneath the building slab.

IBM and SHPC implemented several design and operational changes to certain HVAC systems to increase air exchange rates and room air pressure. These engineered changes successfully achieved significant reductions in indoor VOC concentrations within the areas that directly overlie higher subslab VOC concentrations. The HVAC modifications also resulted in significant reductions in VOC concentrations in other areas of the building that do not directly overlie the area of higher subslab VOC concentrations. Collectively, these results indicate that:

a. The origin of certain VOCs detected in the building, principally PCE, was primarily associated with the intrusion of vapors from certain areas of higher VOC concentrations beneath the Building 310 floor slab; and

b. VOC concentrations detected in building space outlying the main area of higher subslab VOC levels were a consequence of mixing within the building and not of the direct intrusion of vapors through the slab.

Other VOCs detected in indoor air sampling that are likely attributable in part to a subslab vapor presence include trichloroethene, cis-1,2-dichloroethene, and Freon 113. Compounds whose presence can be correlated with ambient outdoor air quality conditions include Freon 11, Freon 12, benzene, toluene, xylenes, and carbon tetrachloride. Acetone is routinely used in the building and was also detected in indoor and outdoor air samples.

2.0 BACKGROUND INFORMATION

This section presents an overview of background information relevant to the Building 310 VOC source assessment, including building information and HVAC system configuration and operational data.

2.1 Building 310

Building 310 is a single-story building constructed in 1963 and 1964 with an approximate gross footprint of 330,000 square feet (sq ft). The building was IBM's first manufacturing building at the Site and has a long history of chemical use associated with the production of microelectronics. Currently, the building is used for warehousing, offices, laboratories, and limited manufacturing in certain areas. Significant portions of the building are vacant, including former manufacturing areas which, as described in more detail later in the report, correspond to areas of higher subslab VOC concentrations. Figure 3 shows the current general use of building space.

2.1.1 Former Chemical Use and Infrastructure

Based upon a review of records, past chemical use in Building 310 has involved a variety of solvents, including PCE, trichloroethene, methylene chloride, acetone, xylenes, isopropyl alcohol, and chlorofluorocarbon 113 (also known as Freon 113/TF or 1,1,2-trichloro–1,2,2-trifluoroethane). In addition, strong acids including hydrogen fluoride, and heavy metals, such as lead, tin, and chromium, were also used.

Historical building plans indicate a network of subslab pipelines for acids, solvents, and fluoride. In addition, floor trenches, sumps, and lift stations are indicated on historical plans. The original chemical and waste handling infrastructure consisted of single-wall piping with no secondary containment or leak detection.

Historical Site plans also show past locations of above ground and underground storage tanks (USTs) associated with virgin or waste solvent. As shown on Figure 3, beneath the current footprint of the groundwater extraction and treatment system housed in Building 384 and just south of the linkway between Building 310 and Building 308, a 15,000-gallon "waste solvent" UST was removed prior to 1986. Two 20,000-gallon USTs located north of the linkway were closed in place after being filled with sand and topped with concrete. These tanks were associated with recovery of spent PCE from manufacturing operations on the northeast side of Building 310. In addition, UST capacity totaling tens of thousands of gallons of both virgin and waste solvents was located within the former tank farm located outside the northeast corner of Building 310 to support Building 310 manufacturing operations.

2.1.2 Remediation and Regulatory Status

The presence of VOCs in the subsurface near Building 310 was discovered in 1979. These VOCs consisted principally of PCE, its breakdown products, and Freon 113. The subsurface presence of VOCs has since been defined in soil and groundwater on the east side of Building 310, centered on the linkway between Building 308 and Building 310 in the area of historical USTs and subsurface pipelines. This general area where VOCs are present in the subsurface came to be known as remediation "Area A" under the Site's Part 373 Hazardous Waste Management Permit (Part 373 Permit). The subslab drain lines beneath Building 310, including those formerly used to convey waste solvent, are identified as inaccessible solid waste management units (SWMUs) in the Part 373 Permit.

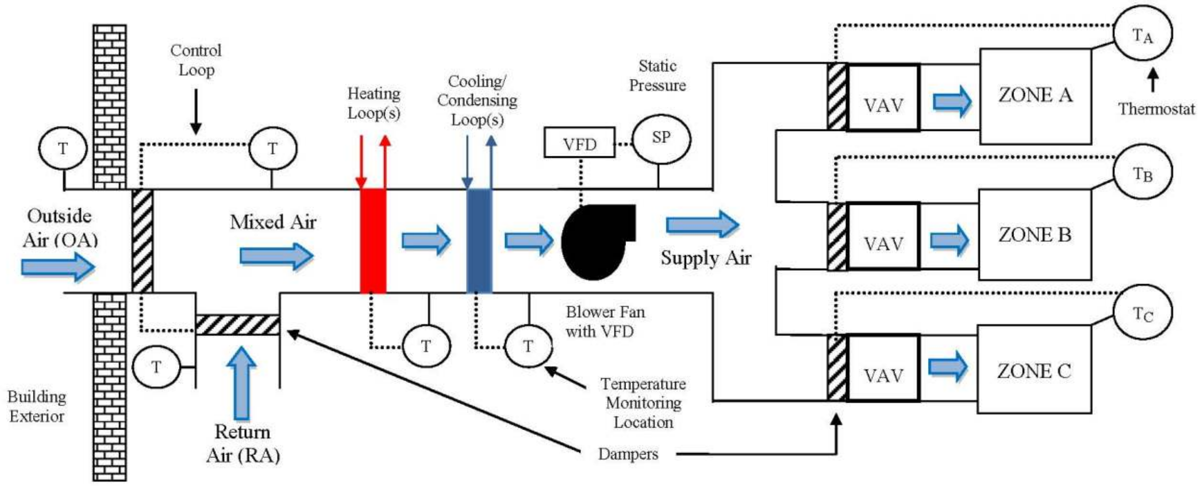
In 1986, IBM constructed a groundwater recovery and treatment system in Building 384 above the footprint of the former waste solvent UST. This system, which continues to operate today under the Part 373 Permit, is focused on extraction and treatment of VOC-containing groundwater perched on a discontinuous layer of glaciolacustrine silt/clay. The water is treated by packed-tower air stripping.

2.2 HVAC System Overview and Terminology

The HVAC system in Building 310 includes 13 air handling units (AHUs), each of which serve distinct areas of the building, as shown on Figure 3. Figure 3 also shows that several portions of the building are presently vacant, including two former manufacturing areas in the eastern central area. HVAC is typically inactive in vacant areas and in areas used for long-term, non-chemical storage. A few areas are served by exhaust fans only, such as the north and south mechanical equipment rooms (MERs) along the east side of the building.

The typical configuration of each AHU is shown below in Exhibit 1 and summarized as follows. Outside air (OA) is drawn into the AHU along with air recycled from the building space, which is known as return air (RA). The mixed outdoor and return air then passes through heating and cooling coils before entering the fan, which discharges the conditioned air, known as supply air, to the building space. In Building 310, the supply air is typically directed through variable air volume (VAV) boxes, which feed the subzones served by the AHU, typically through diffusers in the ceiling. A thermostat in each subzone is interconnected with a damper on the VAV box to increase the flow of supply air to the subzone if required to meet the thermostat set point. In a typical setup, a variable frequency drive (VFD) adjusts the fan speed to provide the supply air flow required to maintain a static pressure set point.

Exhibit 1 - Typical HVAC System Schematic for Building 310



The outside air and return air ducts on most of the AHUs are equipped with dampers that are inversely interlocked to regulate flow – e.g., if the OA damper is 75% open, then the RA damper is 75% closed. The OA dampers are configured or programmed for a minimum open position so that outdoor air is continuously introduced to the building space. On a few of the AHUs, the OA dampers can only be operated manually and are set at a fixed open position.

For the AHUs equipped with automatically modulating dampers, in order to increase the energy efficiency associated with the heating and cooling of outside air, if the outside air temperature or relative humidity is beyond a pre-set range, the dampers are programmed to close to their minimum open position. Otherwise, the dampers are programmed to modulate position to achieve an air temperature set point in the mixed outdoor and return air.

A useful parameter for the assessment of HVAC system operation and indoor air quality is the air changes per hour (ACH), defined as:

$$ACH = \frac{Q}{V}\left(\frac{ft^3}{\min}\cdot\frac{1}{ft^3}\right)\cdot\frac{60}{1}\left(\frac{\min}{hr}\right) = hr^{-1}$$

where Q is the outdoor air flow rate and V is the volume of the HVAC zone. The target ACH for a zone depends on the number of occupants and the use/activity within the zone (e.g., offices, laboratories, clean rooms, etc.). The ACH for buildings Site-wide ranges from approximately 0.2 to 10 hr^{-1}, with office space typically at the lower end of the range and clean rooms typically falling in the mid- to upper part of the range. The outdoor ACH for Building 310 within active HVAC zones ranges from about 0.2 to 7 hr^{-1}, with an average of 2 hr^{-1}, as calculated for the condition that the outside air dampers are in minimum open position. In vacant or long-term storage areas, the outdoor ACH is likely to be lower where AHUs are inactive and where there is no active ventilation.

3.0 VOC SOURCE ASSESSMENT STEPS AND FINDINGS

A VOC source assessment was initiated in October 2008. The initial assessment efforts included a broad coverage of the building footprint, with subsequent focus on the eastern central portion of the building. The VOC source assessment included the following steps:

- Field screening of indoor air using a hand-held instruments;
- Sampling of indoor air within various rooms and areas using Summa canisters and passive diffusion devices;
- Sampling of ambient outdoor air using Summa canisters on the roof of Building 310 proximate to certain HVAC system intakes and adjacent to the eastern loading dock;
- Deployment of targeted, floor-level and breathing zone passive diffusion sampling devices;
- Subslab differential pressure monitoring and vapor sampling; and
- Subslab vapor extraction testing.

Additional investigations and testing included the screening of former solvent drains, sampling of floor slab concrete cores, soil sampling at subslab extraction port locations, and a focused assessment of certain HVAC system zones and operation.

Further details and discussion of the investigation methods and findings are presented below in the general sequence they were conducted. The sampling and lab analyses were conducted in accordance with the investigation procedures and protocols provided in the Work Plan, Appendix A. Field records and documentation are provided in Appendix C of this report, and copies of laboratory analytical reports are provided in Appendix D.

3.1 Initial Screening

The initial screening of indoor building space and building features was conducted using handheld photoionization detectors (PIDs). These field devices report results in units of parts per billion by volume (ppbv), with a detection limit for PCE on the order of 0.7 ppbv. For PCE, 1 ppbv is equivalent to approximately 6.9 $\mu g/m^3$ at 20º Celsius and 1 atmosphere pressure. In addition, selected areas and building features were screened using an infrared gas detection instrument[2] capable of tentatively identifying individual VOCs. This field device has a detection limit for PCE of 90 ppbv, or about 620 $\mu g/m^3$, and was used to further screen possible PCE sources.

[2] Miran SapphIRe Model XL manufactured by Thermo Scientific.

As shown on Figure 4, the PID screening results within the breathing zone throughout Building 310 ranged from less than 1 ppbv to approximately 500 ppbv, with an isolated reading of 2,000 ppbv in a closed room of a former manufacturing area. The relatively higher PID concentrations were recorded intermittently throughout the former manufacturing areas and closed storage areas in the central and northern portions of the building, where the HVAC systems are inactive.

The PID field device was also used to screen various accessible building features, including sumps, tile cracks, floor penetrations, chemical drain covers (with and without the covers removed), and beneath raised floors. The PID values observed in this screening ranged from less than 1 ppbv to 25,000 ppbv. The high value was observed within an abandoned solvent floor drain. Similar PCE concentrations were detected using the infrared instrument, the results of which are shown on Figure 7. At most locations, however, PID screening of the breathing zone did not indicate the presence of VOCs, even in areas where relatively higher PID readings were recorded for certain building features. Further discussion of PID screening of the solvent drains is provided in Section 3.7.1.

3.2 Indoor Air Sampling and Laboratory Analysis

Indoor air samples were collected over multiple events at a broad array of sampling locations within Building 310. The sampling dates and results are provided in Table 1 and discussed below.

The initial sampling event was conducted on February 17, 2009 and consisted of 17 indoor air samples collected into 6-liter Summa canisters equipped with 8-hour flow controllers. The sample locations were selected based on the PID screening data, in conjunction with a desire to provide broad coverage of the building. Concurrent with the February 17th sampling event, SHPC collected 7 ambient outdoor air samples on the Building 310 roof and at the eastern loading dock, as described in the next section.

Figure 5 shows the PCE concentrations detected in the February 17, 2009 indoor air samples. In addition, two indoor air samples were collected in the north mechanical equipment room (MER) on April 1, 2009 and are also included on the figure.

As shown on Table 1, PCE was detected in all the indoor samples, with the concentrations ranging from 4.1 $\mu g/m^3$ to 2,800 $\mu g/m^3$. The PCE concentrations were generally greater for samples collected from the eastern central area of the building, with the highest concentration detected in an unoccupied and unvented storage room proximate to the Building 310/308 linkway. This room is located within an inactive HVAC zone, where an existing ceiling exhaust fan was not in operation and there was no perceptible air flow within the room.

As shown in Table 1, the air samples contained several constituents in addition to PCE, including the chlorinated ethenes trichloroethene (TCE) and cis-1,2-dichloroethene (cDCE); chlorofluorocarbons (Freon 11, Freon 12, and Freon 113); aromatic hydrocarbons (benzene, toluene, xylenes); as well as acetone and small quantities of carbon tetrachloride. As further discussed below, several of these compounds were also detected in outdoor air samples at concentrations similar to those in indoor air.

3.3 Ambient Outdoor Air Sampling and Laboratory Analysis

Seven ambient outdoor air samples were collected concurrent with the February 17, 2009 indoor air sampling. Six of the ambient outdoor samples were collected on the rooftop of Building 310 and one sample was collected outside of the loading dock area on the eastern side of Building 310. The rooftop samples were positioned to collect air entering the outside air intakes of certain AHUs as shown on Figure 6.

The air stripping tower associated with the Area A groundwater treatment system, which is located in Building 384 to the east of Building 310 (see Figure 6), was shut down 24 hours prior to and during outdoor and indoor air sampling.

As shown on Figure 6, PCE was detected in 3 of the 7 samples at concentrations ranging from 0.98 to 1.2 $\mu g/m^3$. In addition, Freon 11 and Freon 12 were detected in all outdoor air samples at concentrations ranging from 1.5 to 3.1 $\mu g/m^3$. Other compounds detected in outdoor air included acetone, benzene, and toluene at concentrations ranging from less than 1 to a maximum of 7.8 $\mu g/m^3$. The results for these outdoor air samples are provided in Table 1.

The relative PCE concentrations within the indoor and ambient outdoor samples indicate that the principal source of PCE detected within Building is located within the footprint of Building 310 and cannot be attributed to the ambient outdoor air. While low concentrations of PCE were detected in the ambient outdoor air, Freon 113, TCE, and cDCE were not detected in ambient outdoor air. Freon 11, Freon 12, benzene, and toluene were detected in outdoor air at concentrations generally similar to the indoor air detections. Acetone, which is used in the building, was detected in indoor and outdoor air samples.

3.4 Targeted Passive Diffusion Sampling and Laboratory Analysis

Passive diffusion (PD) samplers were used to help identify potential sources of PCE detected in the Building 310 indoor air. Several sampling events were conducted with PD devices, with the sample locations focused on the areas identified from PID screening and indoor air sampling, i.e., the eastern central portion of Building 310. The sampling locations and results of these events are provided on Figure 7 and summarized in Table 2.

The PD samplers were deployed on the floor and within features in the former manufacturing areas, in the north mechanical equipment room (MER), and the abutting storage room. PD samplers were deployed to provide general coverage of suspect areas, and to target specific building features like cracked floor tiles or waste drain covers, specifically those that exhibited PID and infrared gas detector screening detections (locations and results shown on Figure 7). The PD sampling events are discussed in greater detail below.

- On November 9, 2008, nine PD samplers were deployed at several locations including the former manufacturing areas, a former solvent storage room, and in the hallway adjacent to the linkway between Building 310 and Building 308. The PD samplers were placed face down on the floor, with the exception of PD-04, which was deployed face up on an elevated surface. PCE concentrations ranged from less than 100 $\mu g/m^3$ (non-detect) to 9,500 $\mu g/m^3$ (on a floor penetration in a former manufacturing area), as listed on Table 2.

- On April 1, 2009, 20 PD samplers were deployed throughout the north MER, an abutting storage room currently containing computers, and a former chemical storage room. The PD samplers were deployed face down, with the exception of two PD samplers placed in the breathing zone that were collocated with and concurrent to Summa canister samples. PCE concentrations for the floor-level samples ranged up to 1,900 $\mu g/m^3$ (near a floor sump on the eastern edge of the MER), as listed on Table 2.

- On May 13, 2009, 38 PD samplers were deployed throughout the former manufacturing areas. The PD samplers were placed on the floor in face down/face up pairs, in sumps, and within the breathing zone (collocated and concurrent to Summa canister samples). PCE concentrations for the floor-level samples ranged up to 3,200 $\mu g/m^3$ (within a floor sump).

The PD sampling data, shown on Figure 7 and summarized in Table 2, indicate higher PCE concentrations at certain locations along former chemical drain lines or near covered sumps, and generally lower concentrations in samples at floor-level collected for general coverage. The data from the paired PD samplers generally indicate higher PCE concentrations detected by the PD sampler deployed face down as compared to the PD sampler deployed face up. These data indicate that legacy and/or subslab VOC sources are likely present within the eastern central portion of Building 310 and contributing to the observed presence of PCE in indoor air.

3.5 Subslab Port Installation, Testing, and Sampling

A subslab vapor investigation was conducted during the week of May 4, 2009. This work focused on the eastern central portion of the building, and also included several additional subslab measurement locations to provide broad coverage of the building.

Figure 8 shows the locations of the 22 subslab ports that were installed in May 2009. Ten of the ports (SS-01 through SS-10) were installed with 1-inch diameter fittings to accommodate subslab vapor extraction testing, in addition to differential pressure monitoring and subslab vapor sampling. These 10 ports were centered on the eastern central area of the building. The remaining 12 ports (SS-11 through SS-22) were installed with 0.25-inch diameter ports for differential pressure monitoring and subslab vapor sampling. Construction details and integrity/leak testing for the subslab ports are described in the installation procedures provided in the Work Plan, Appendices A.6 and A.7.

3.5.1 Subslab Differential Pressure Monitoring

Measurements of the subslab pressure relative to the room air pressure were obtained at subslab port locations using digital micro-manometers. These instruments have an operating range from 0.001 to 1.0 inches of water column (in. wc). The results, shown on Figure 8, indicate generally neutral pressure differentials across the floor slab (within a few thousandths in. wc), except in the north MER, where the subslab pressure was greater than the room air pressure. The higher subslab pressure relative to indoor pressure in this room was likely due to the operation of two active ceiling exhaust fans. IBM has subsequently reconfigured the MER ventilation system to reduce the pressure differential across the floor slab beneath this room, as further described in Section 4.4.

3.5.2 Subslab Vapor Sampling

Figures 9 and 10 show the PCE and Freon 113 concentrations recorded for the subslab vapor samples that were collected on May 5 and May 6, 2009. The subslab samples were collected into 1-liter Summa canisters using 1-hour laboratory calibrated flow controllers[3]. The subslab vapor sample data are summarized in Table 3. PCE and Freon 113 were the compounds typically detected at the highest concentrations in subslab vapor. Other compounds detected, typically at concentrations less than PCE and Freon 113, were (in order of relative frequency) TCE, acetone, Freon 11, cDCE, toluene, Freon 12, 1,1,1-trichloroethane, 1,1-dichloroethene, methylene chloride, benzene, and xylenes.

As shown on Figures 9 and 10, the subslab vapor presence of PCE and Freon 113 is centered within a region beneath the former manufacturing area in the eastern central portion of the building. The highest PCE concentrations are on the order of 1 million μg/m^3 as detected in samples from ports SS-06 and SS-08. The subslab concentrations decrease with increasing distance from the region around SS-06 and SS-08, with the exception of an area in the southeastern part of Building 310 centered on port SS-21, where relatively higher PCE and Freon 113 were detected as compared to the sampling ports nearest this location.

Figures 9 and 10 also show the historically inferred patterns of VOCs in overburden groundwater along the east side of Building 310 currently being managed by the Area A groundwater recovery and treatment system housed in Building 384. The highest observed subslab PCE vapor concentration of 1,000,000 μg/m^3 is consistent with what would be expected from equilibrium partitioning of aqueous-phase PCE at about 1,700 μg/L[4].

To assess whether the detected subslab PCE vapor concentrations could account for the observed concentrations of PCE in indoor air, SHPC estimated the possible magnitude of the mass flux through the floor slab by diffusion alone. At a subslab PCE vapor concentration of 1,000,000

[3] These 1 hour time-weighted-average samples collected using Summa canisters provide VOC reporting limits, shown on Table 3, that are appropriate to identify subslab VOC sources.

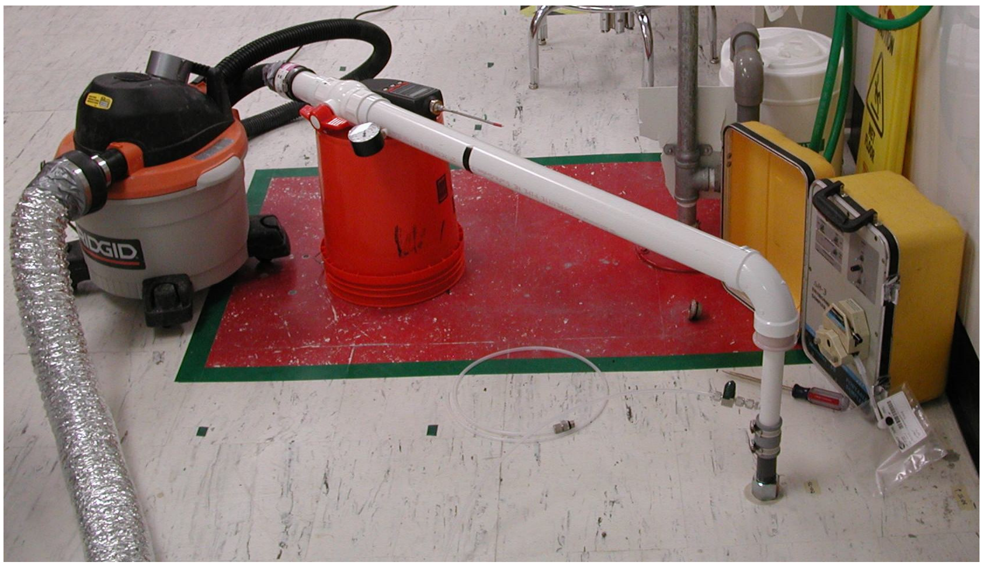
[4] See Appendix B, Calculation 1.

μg/m^3, the diffusive mass flux through the floor slab is estimated to be on the order of 860 μg/m^2/hr.[5] At an ACH of 1 hr^{-1} for the overlying building space, the estimated PCE concentration[6] in indoor air would be about 300 μg/m^3, which is on the order of the observed PCE concentrations prior to the HVAC modifications (sample locations IA2009 at 370 μg/m^3 and IA2010 at 630 μg/m^3).

3.6 Subslab Vapor Extraction Testing

Subslab vapor extraction testing was performed at extraction ports SS-01 through SS-10 on May 6 through May 8, 2009. This testing was conducted to assess the method as a potential source reduction/remediation measure to remove VOC mass from beneath the floor slab. A shop-vacuum and temporary piping/hose, as shown in Exhibit 2, was used to extract vapor from below the slab at each location for test durations ranging from 30 to 65 minutes. Extraction rates ranged from 11 to 60 cubic feet per minute (cfm) at applied vacuums ranging from 20 to 52 in. wc.

Exhibit 2 - Subslab Extraction Testing Set-Up



Extraction testing conditions and pressure response results are shown on Figure 11. During the tests, samples of the extracted vapor were periodically collected into Tedlar bags and screened using a PID. Samples were also collected into Summa canisters near the conclusion of each extraction test. The screening and sampling data for each test are presented in Exhibit 3 below, and the complete analytical results for the extraction test vapor samples are provided in Table 3

[5] See Appendix B, Calculation 2.

[6] See Appendix B, Calculation 3.

Exhibit 3 – Subslab Vapor Extraction – PID Screening and Sampling Data

Port Location	PID Screening		Total VOCs - Summa Samples	
	Initial [ppmv]	Final [ppmv]	Final [ppmv]	Final [ug/m3]
SS-01	50	57	84	570,000
SS-02	580	29	4.6	31,000
SS-03	14	10	0.25	1,700
SS-05	20	33	16	110,000
SS-06	230	140	150	1,000,000
SS-07	5.3	27	1.7	12,000
SS-08	630	580	550	3,900,000
SS-09	8.6	20	0.024	140
SS-10	3.3	29	1.6	11,000

At half the test locations, the final PID screening reading was greater than the initial reading, which suggests that in these cases, higher VOC vapor concentrations were present further away from the extraction port and were being drawn to the extraction port as the test proceeded.

The PCE concentrations at the end of each test ranged from 55 $\mu g/m^3$ (at SS-09) to 2,800,000 $\mu g/m^3$ (at SS-08). Assuming these PCE concentrations as the average PCE concentration for the test duration, the PCE mass removed from the subslab at each location ranged from approximately $3x10^{-6}$ to 0.3 lbs per hour at flow rates of 12 and 30 cfm, respectively.

Figure 11 shows the subslab pressure response observed near the end of each test when pressure readings had generally stabilized. These data indicate generally limited subslab vacuum response to extraction conditions. The generally limited extent of measurable vacuum is consistent with the modest rate of extraction and may also reflect the presence of building foundation elements (grade beams), floor trenches, and sumps that likely act as barriers to flow or boundary conditions limiting expansion of the vacuum field.

Additional longer-duration subslab vapor extraction testing with a higher capacity blower system, enabling higher vacuum and flow rates would be required to further assess potential for mass removal and pressure gradient control.

3.7 Other Investigation and Testing Results

Several other investigation steps were conducted to assess potential sources of PCE detected in the indoor air of Building 310, including review and screening of certain closed solvent drain lines, sampling of concrete cores and soil collected during installation of the vapor extraction test ports, and focused assessment of HVAC system operations, particularly in areas of relatively higher indoor air PCE concentrations. These investigations and their results are described below.

3.7.1 Screening of Former Solvent Drains

Building 310 was constructed with three networks of subslab drain lines for industrial waste associated with former manufacturing operations, including acid drains, fluoride waste drains, and solvent waste drains. All three networks extend into the former manufacturing areas. It has been reported that historical integrity testing indicated evidence of breaches, but the exact locations are unknown. These drains were removed from service and cleaned in place by the mid to late 1980s.

To assess the possibility that the subslab piping could represent a conduit for vapor migration from the subsurface to the building space, SHPC conducted PID screening and collected PD samples at select accessible drains in the former manufacturing areas. Where possible, the drain covers and caps were removed and the drain lines were screened directly with a PID. The PID screening and PD data indicated concentrations of PCE that were greater than that observed for indoor air; however, the concentrations found in these lines indicated conditions well below saturated vapor concentrations that would be expected if residual solvent was present.

3.7.2 Concrete Slab and Soil Sampling

Samples of the concrete cores were collected during installation of the ten vapor extraction ports for laboratory analysis to assess for residual solvent presence that could be a contributor to the observed PCE presence in indoor air. Following removal of the concrete core from each extraction port location, a soil sample was collected using a hand-held Geoprobe sampler with a 2-ft-long Macrocore sampler. The samples were collected from a depths ranging from 0.4 feet to 1.6 feet below floor level.

The locations of the concrete core and soil samples, and associated laboratory analytical results, are shown on Figure 12 and provided in Table 4. For the concrete samples, laboratory analysis indicated PCE at concentrations ranging from less than 5 micrograms per kilogram (µg/Kg) to 20 µg/Kg. SHPC believes that these concentrations are not sufficient to support off-gassing of PCE from the concrete alone as a principal source for the PCE presence observed in indoor air.

PCE was detected in soil samples at concentrations ranging from less than 5 µg/Kg to 950 µg/Kg, with a mean of about 190 µg/Kg. Higher PCE levels in soil were detected in the eastern central portion of the building, where higher subslab vapor concentrations were detected. As shown in the graph inset on Figure 12, PCE presence in the soil and concrete samples does not appear to be correlated.

At a mean PCE soil concentration of 190 µg/Kg, the estimated equilibrium aqueous-phase PCE concentration is 200 µg/L[7], and the estimated equilibrium PCE vapor concentration is about 120,000 µg/m^3. The estimated vapor concentration is within an order of magnitude of the actual PCE vapor concentrations detected at most of the locations where both soil and vapor samples were collected.

[7] Calculated assuming a total porosity of 0.4, water content of 0.058 (from soil sample analytical results), a fractional organic carbon content of 0.005, and a K_{oc} of 0.155 for PCE.

3.7.3 Comparison of Sampling and Analytical Methods

Exhibit 4 below presents comparative data for collocated indoor air samples collected in the north MER and former manufacturing areas using the following sampling and analytical methods:

- 8-hour time-integrated samples collected using Summa canisters and analyzed in accordance with modified USEPA Method TO-15 by Air Toxics, Ltd. of Folsom, California; and

- 24-hour time-integrated samples collected using PD sampling devices at breathing zone height and analyzed in accordance with modified NIOSH Method 1003 by Galson Laboratories of East Syracuse, New York.

Exhibit 4 - Comparison of Data from Different Analytical Methods

Sample ID	Sample Date	PCE	
	Units	ug/m^3	
	Analytical Method	NIOSH Method 1003	TO-15
	Sampling Device	Passive Sampler	Summa Canister
PD-01_2009/IA2025	4/1/2009	540	140
PD-02_2009/IA2026	4/1/2009	200	95
PD-28_2009/IA2030	5/13/2009	<100	7.1
PD-39_2009/IA2031	5/13/2009	<100	4.3
PD-43_2009/IA2027	5/13/2009	<100	7.7
PD-48_2009/IA2009	5/13/2009	<100	7.4

As indicated above, the PD sampling data generally correlate with the Summa canister data. Differences in concentrations among the methods are likely due to the different sampling durations and variations in placement of the different sampling devices, in conjunction with normally expected levels of instrument analytical variability.

3.7.4 Assessment of Indoor Air Data Against HVAC System Operations

An assessment of HVAC system configuration and operation was conducted, with a focus on the areas of particularly anomalous indoor air PCE concentrations in the eastern central portion of the building. This assessment included estimating air exchange rates, or air changes per hour (ACH), for the HVAC zones. The areas that exhibited relatively higher indoor PCE levels were also areas where the ACH was relatively low. Specific findings are as follows:

- The highest PCE concentration detected in indoor air during the February 2009 sampling event (2,800 $\mu g/m^3$ at location IA2011 – see Figure 5) was detected in a room used for computer hardware storage. This room is rarely accessed, and the door is normally closed and locked. When the room was opened for sampling, air movement was not discerned. No HVAC supply air is ducted to this room. Two ceiling exhaust fans were observed in this room, but only one was subsequently found to be functional and it was not operating. With no measurable air movement through the room, the actual ACH cannot be calculated, but SHPC estimates that the ACH would be on the order of about 0.01 hr^{-1}. At this ACH, the diffusive flux through the floor slab resulting from a subslab PCE concentration of 100,000 $\mu g/m^3$ (consistent with the detected PCE concentration at the nearest subslab port SS-05) would be sufficient to account for the indoor PCE concentration of 2,800 $\mu g/m^3$ detected in the storage room.

- The highest PCE concentration detected in human-occupied space during the February 2009 sampling event (630 $\mu g/m^3$ at location IA2010 – see Figure 5) occurred in a maintenance shop office area proximate to the computer storage room and across a hallway to the south of the vacant former manufacturing areas. This area is served by an active AHU identified as AC-32. The ACH for this area was estimated to be about 1 hr^{-1}. At this ACH, the diffusive flux through the floor slab resulting from a subslab PCE concentration of 1,000,000 $\mu g/m^3$ (consistent with the detected PCE concentration at the nearest subslab port SS-06) would be sufficient to account for the indoor PCE concentration of 630 $\mu g/m^3$ detected in the office space.

- Six return air chases were identified proximate to indoor air sample location IA2015 and subslab port SS-21 within the HVAC zone served by AC-30 along the southeastern side of the building. These return air chases were constructed such that the floor functions as part of the air duct system. This configuration causes air pressure within the chases to be less than that below the floor slab. While the VOC levels in this area were not particularly greater than in other areas of the building, the presence of the chases can create a driving force for subslab vapor to potentially enter the HVAC system. No other return air chases in contact with the floor were identified in Building 310; the majority of the return air is drawn from the plenum space above the hung ceiling throughout the building. The ACH for the storage room where sample IA2015 was collected was estimated to be about 0.3 hr^{-1}. At this ACH, the diffusive flux through the floor slab resulting from a subslab PCE concentration of 56,000 $\mu g/m^3$ (consistent with the PCE concentration detected at the nearest subslab port SS-21) would be sufficient to account for the indoor PCE concentration of 72 $\mu g/m^3$ detected in the storage space.

- The north mechanical equipment room (MER) is served by two ceiling exhaust fans. By design, no HVAC supply air is fed to the room because the exhaust fans operate year-round to dissipate heat from the equipment. Differential pressure measurements indicated that the room air pressure was negative relative to the subslab pressure, the adjacent hallway, and outside air pressure. The PCE levels detected in indoor air in this room (see locations IA2025 and IA2026 on Figure 5) were greater than expected based on diffusion of mass through the floor slab, assuming an average of about 200,000 $\mu g/m^3$ of PCE below the slab and an ACH of 8 hr^{-1} estimated from the exhaust flow from the room. The negative room air pressure relative to subslab would support the potential for advective mass transport from the subslab to the room, which may in part explain the indoor PCE data in this area.

In response to these observations, IBM performed certain modifications and adjustments to the HVAC system as described in Section 4.0.

3.8 Summary of Assessment Findings

The findings of the assessment are summarized as follows:

- Building-wide indoor air sampling in February 2009 indicated anomalous PCE concentrations at several locations in the central eastern portion of the building. The anomalous indoor PCE concentrations coincided with a region that overlies higher PCE presence in subslab vapor, and where ACH was found to be relatively low. The overall pattern of lower PCE detections in indoor air with distance from the cental portion of the building is consistent with dispersion and mixing from this area due to HVAC operations.

- VOC-containing vapor, predominantly PCE and Freon 113, is present below the floor slab centered beneath the vacant former manufacturing areas in the central eastern portion of the building. The highest observed subslab PCE vapor concentration of 1,000,000 $\mu g/m^3$ is consistent with what would be expected from equilibrium partitioning from aqueous phase PCE presence at about 1,700 µg/L at 20ºC;

- Estimates derived from a simplified analytical solution suggest that VOC diffusion through the slab is sufficient to support the observed PCE concentrations in indoor air in areas where air movement is not discernable or air exchange rates are relatively low;

- Although lab testing of floor slab concrete confirmed the presence of PCE in the concrete, the results do not indicate PCE concentrations that would solely account for the observed concentrations in indoor air. Soil samples collected from beneath the slab indicated the presence of PCE at concentrations consistent with the subslab PCE vapor concentrations.

Given these findings, IBM implemented the measures described below.

4.0 MEASURES COMPLETED AND RESULTS

IBM implemented measures to increase ventilation and air exchange in areas of Building 310 where air movement was not perceptible or where anomalous VOC concentrations in indoor air were detected. As shown on Figure 13, as a result of these actions, VOC concentrations in indoor air have decreased significantly compared to the initial sampling results of February 2009. Table 1 provides a complete tabulation of the laboratory results for the indoor air samples in Building 310, and Figure 14 shows a summary of the PCE concentrations at all indoor sampling locations and sampling events.

Table 5 and Exhibit 5 below summarize the areas where measures were implemented, and they include the ACH and PCE data for these areas before and after these measures were taken.

Exhibit 5 – Summary of ACH and PCE Data Before and After HVAC Modifications

Sample ID	Location	Nearest Column	HVAC Zone	Before HVAC Mods ACH (hr^{-1})	Before HVAC Mods PCE (ug/m^3)	After HVAC Mods ACH (hr^{-1})	After HVAC Mods PCE (ug/m^3)	% Reduction in PCE Concentration
IA2011	Computer storage room	C-12	None	0.01	2800	13	58	98%
IA2010	Maint. office	F-12	AC-32	1.0	630	6.8	37	94%
IA2015	Storage room	B-22	AC-30	0.31	72	2.5	2	97%
IA2034	Tool shop	B-22	AC-30	0.9	Not sampled	7.4	<1.2	Not available
IA2025	North MER	C-11	None	8.1	140	7.0	75	46%
IA2006	DI water room	R-7	AC-4	0.01	67	3.1	38	43%
IA2002	Work room	F-3	AC-15	1.2	13	2.3	4.6	65%

Further description of the measures taken and their effects are provided below.

4.1 Ventilation of Computer Storage Room

To increase the ACH of the unoccupied storage room at column C-12, where the highest PCE concentration had been detected in indoor air, IBM activated the ceiling exhaust fan and installed two ventilation transfer fans through the wall between the room and the adjacent corridor. As a result, the ACH for the room increased to about 13 hr^{-1} estimated based on the transfer fan flow into the room. As shown on Figure 13, the most recent sampling of location IA2011 after increasing the ACH indicated a reduction in the PCE concentration to 58 $\mu g/m^3$.

4.2 AC-32 Modifications and Results

Prior to implementing modifications to AC-32, the highest PCE concentration detected in routinely occupied space occurred in the maintenance shop office at column F-12. This area is served by an active AHU identified as AC-32. Prior to modifications, the AC-32 outdoor air intake damper would automatically modulate, and could be open as little as 20% (the minimum open position) depending on outdoor temperature conditions. The ACH for the office area when the damper was in minimum position was estimated to be about 1 hr^{-1}.

To increase the ACH, IBM modified the operation of the AC-32 outdoor intake damper to maintain position at a constant 100% open condition. In addition, the supply air ducting to the office was reconfigured for better air distribution, increasing the flow to the office area from about 720 cfm to 1,000 cfm. As a result, the ACH for the room increased to about 6.8 hr^{-1}. As shown on Figure 13, the most recent sampling of location IA2011 after increasing the ACH indicated a reduction in the PCE concentration to 37 $\mu g/m^3$. This reduction in concentration is greater improvement than estimated based on increased air exchange alone[8], and could be due in part to increased room air pressure due to the increase in supply air flow rate.

[8] Assuming the room is a well-mixed system, the indoor concentration after changing the ACH can be estimated from the ACH before and after the change, according to the relationship $C_{after} = C_{before} * (ACH_{before}/ACH_{after})$. For the storage room, this relationship predicts $C_{after} = 630\ \mu g/m^3 * (1.0/6.8) = 93\ \mu g/m^3$.

4.3 AC-30 Modifications and Results

The HVAC zone served by AC-30 along the southeastern side of the building overlies a localized area of relatively greater subslab VOC concentrations (see subslab port SS-21 on Figure 9). Field reconnaissance of a tool shop and abutting storage room near column B-22 identified six return air chases constructed such that the floor functions as part of the air duct system, which provides a potential pathway for subslab vapor to enter the HVAC system. The ACH for the tool shop and the storage room based on outdoor air flow was calculated to be relatively low at 0.9 hr^{-1} and 0.3 hr^{-1}, respectively.

To address the relatively low ACH and the atypical construction of the return air chases, IBM took the following actions:

- The supply air flow to the tool shop and abutting storage area was increased by opening a manual damper from 60% to 100% open;
- The AC-30 outdoor air intake damper, which was manually set at 20% open, was adjusted to maintain position at a constant 80% open condition;
- "Bleed/relief air" flow was added to the discharge side of the AC-30 AHU to exhaust a portion of the return air from the tool shop to outdoors; and
- The return air chases were de-coupled from the floor such that the floor no longer comprises part of the return air ductwork.

After completing these actions, sampling of the storage room indicated a reduction in the PCE concentration to 2 $\mu g/m^3$.

4.4 Ventilation of North Mechanical Equipment Room (MER)

To address the negative room air pressure in the MER relative to the subslab, adjacent corridor, and outdoors, a ventilation fan was installed through the wall separating the corridor along column D from the MER. This fan transfers building air from the corridor into the room. In addition, the larger of the two ceiling exhaust fans (B-11) was shut down. These adjustments increased the pressure of the room relative to the subslab and the outdoors. As shown on Figure 13, sampling of the MER following the above modifications indicated a modest reduction in the indoor PCE concentration at location IA2025. Pressure monitoring indicated that after these changes, the pressure gradient across the floor slab was still directed into the MER from beneath the slab. This condition is likely due to the continued operation of at least one exhaust fan necessary to dissipate heat from the MER.

4.5 Other HVAC Modifications

HVAC modifications were completed in certain other areas of the building to increase air exchange and room air pressure. These modifications and the results were as follows:

- In the DI water equipment room in the central part of the building near column R-7, supply air was ducted to the room to increase room air pressure and air exchange. As shown on Figure 13, the most recent sampling at location IA2006 following these modifications indicated a reduction in the PCE concentration to 38 µg/m^3.

- The minimum position for the AC-15 outdoor air intake damper was adjusted from 25% open to 50% open. The objective was to increase outdoor ACH in the northeast corner of Building 310, including the corridor along column line D from where the new transfer fans draw to feed the MER and computer storage room. As shown on Figure 13, the most recent sampling at location IA2002 indicated a reduction in the PCE concentration to 4.6 µg/m^3.

4.6 Summary of Post-HVAC Modification Results

In summary, as shown on Figure 13, after completing the HVAC modifications described above, PCE concentrations have decreased throughout the building. The PCE concentration reductions in the affected areas are shown on Table 5 are generally consistent with the expected reductions based on increased ACH. In areas of the building located further away from the region of relatively higher subslab PCE presence, indoor PCE concentrations have also decreased, typically by about a factor of 10, and several locations did not exhibit PCE presence greater than the laboratory reporting limit.

5.0 CONCLUSIONS

The investigation of anomalous indoor air conditions in Building 310 identified the presence of VOCs, principally PCE, in subslab vapor centered beneath former and currently vacant manufacturing areas in the eastern central portion of the building. The observed concentration and pressure gradients across the slab in certain areas are sufficient to support both advective and diffusive transport from the subslab into the building that could explain the VOC concentrations in indoor air where air exchange is limited and not served by active HVAC systems.
IBM implemented measures to increase air exchange in the areas where ACH was found to be relatively low and anomalous VOC concentration were detected in indoor air. Following these measures, VOC concentrations decreased generally consistent with expected reductions based on increased ACH. Building-wide sampling of indoor air also indicated reduced VOC concentrations. Further reductions in indoor PCE concentrations by way of additional HVAC modifications would be difficult given the design and operating constraints of these systems.

IBM plans to maintain the HVAC system modifications (documented in Table 5) at their current condition. In addition, IBM plans to conduct a subslab vapor extraction design feasibility study. The objectives of the study will be to:

- Assess removal of VOC source mass from below the building slab; and

- Evaluate control of air pressure gradients across the slab in certain key areas that have higher potential for VOC transport into the building.

Based on the study results, IBM will evaluate possible design and installation of a subslab vapor extraction system, and/or other appropriate actions. IBM will provide the Agencies with regular updates of progress throughout 2010.

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TABLES

Table 1
Summary of Indoor and Ambient (Outdoor) Air Sampling Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

SAMPLE LOCATION	ANALYTE / DATE	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl Chloride	Freon 12	Freon 11	Freon 113	Methylene Chloride	Carbon Tetrachloride	1,1,1-Trichloroethane	1,1-Dichloroethene	Acetone	Benzene	Toluene	Ethyl Benzene	m,p-Xylene	o-Xylene	Chlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	1,2,4-Trichlorobenzene
INDOOR AIR SAMPLE RESULTS		μg/m³																					
IA2001	02/17/09	68	1.1	<0.69	<0.45	3.0	10	9.7	<1.2	<1.1	<0.95	<0.69	13	0.71	11	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	07/08/09	<1.1	<0.18	<0.65	<0.042	2.0	15	<1.2	<1.1	0.42	<0.89	<0.65	14	<0.52	1.0	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
	11/20/09	16	0.89	<0.68	<0.044	4.7	7.8	4.8	<1.2	0.48	<0.93	<0.68	10	0.88	1.4	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
IA2002	02/17/09	13	1.4	<0.69	<0.45	2.7	4.2	7.0	<1.2	<1.1	<0.95	<0.69	6.0	<0.56	1.2	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	07/08/09	<1.2	1.1	<0.68	<0.044	2.0	4.8	<1.3	<1.2	0.45	<0.93	<0.68	10	0.68	1.6	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	11/20/09	44	2.6	<0.68	<0.044	9.1	4.8	16	<1.2	0.43	13	<0.68	4.7	<0.55	0.83	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	12/17/09	4.6	<0.18	<0.65	<0.042	2.3	2.0	<1.2	<1.1	0.49	<0.89	<0.65	2.4	<0.52	<0.62	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2003	02/17/09	4.1	<0.92	<0.68	<0.44	2.9	3.3	2.3	<1.2	<1.1	<0.93	<0.68	3.6	0.55	<0.64	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	08/26/09	8.8	0.65	<0.68	<0.044	2.2	7.9	6.0	<1.2	0.49	<0.93	<0.68	9.2	<0.55	0.86	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
IA2004	02/17/09	16	<0.85	<0.63	<0.40	2.6	3.3	2.8	<1.1	<0.99	<0.86	<0.63	4.8	0.55	2.5	<0.69	<0.69	<0.69	<0.73	<0.95	<0.95	<0.95	<5.9
	08/26/09	36	2.7	<0.71	<0.046	2.2	17	21	<1.2	0.51	<0.98	<0.71	36	<0.57	1.0	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	11/20/09	25	1.6	<0.69	<0.045	8.1	3.9	8.5	<1.2	0.61	<0.95	<0.69	8.4	1.1	1.7	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	12/17/09	9.0	0.52	<0.65	<0.042	2.9	1.9	1.8	<1.1	0.49	<0.89	<0.65	3.9	<0.52	<0.62	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2005	02/17/09	13	2.1	0.69	<0.44	2.5	3.5	21	<1.2	<1.1	<0.93	<0.68	5.3	<0.55	<0.64	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	06/08/09	23	2.0	<0.71	<0.046	2.5	11	25	<1.2	0.43	<0.98	<0.71	9.7	<0.57	<0.67	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	07/08/09	1.6	0.19	<0.68	<0.044	2.0	3.3	2.0	<1.2	0.44	<0.93	<0.68	5.4	0.73	1.1	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	11/20/09	49	5.0	1.1	<0.044	7.3	4.8	50	<1.2	0.50	<0.93	<0.68	13	0.56	0.79	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	12/17/09	3.9	0.58	<0.65	<0.042	2.4	1.8	2.1	<1.1	0.55	<0.89	<0.65	8.9	<0.52	<0.62	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2006	02/17/09	67	1.3	<0.69	<0.45	2.8	7.9	9.7	<1.2	<1.1	<0.95	<0.69	7.7	<0.56	8.2	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	08/26/09	55	2.8	<0.72	<0.047	2.4	18	24	<1.3	0.50	<1.0	<0.72	13	<0.58	1.8	<0.79	<0.79	<0.79	<0.84	<1.1	<1.1	<1.1	<6.8
	11/20/09	38	1.8	<0.60	<0.039	18	6.0	8.0	<1.0	0.52	<0.83	<0.60	12	0.53	1.2	<0.66	<0.66	<0.66	<0.70	<0.91	<0.91	<0.91	<5.6
IA2007	02/17/09	48	<0.94	<0.69	<0.45	2.5	3.8	2.1	<1.2	<1.1	<0.95	<0.69	7.1	<0.56	7.4	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	07/08/09	<1.2	<0.18	<0.68	<0.044	2.0	4.3	<1.3	<1.2	0.43	<0.93	<0.68	9.8	<0.55	<0.64	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	11/20/09	3.3	0.46	<0.67	<0.043	3.8	2.8	1.4	<1.2	0.58	<0.92	<0.67	7.0	0.59	0.71	<0.73	0.97	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
IA2008	02/17/09	21	<1.0	<0.74	<0.48	2.9	6.2	3.7	<1.3	<1.2	<1.0	<0.74	12	0.68	3.9	<0.81	0.98	<0.81	<0.86	<1.1	<1.1	<1.1	<6.9
	07/08/09	2.4	<0.19	<0.69	<0.045	2.1	12	<1.3	<1.2	0.44	<0.95	<0.69	7.1	0.73	20	<0.76	<0.76	<0.76	<0.8	<1.0	<1.0	<1.0	<6.5
	11/20/09	44	2.0	<0.68	<0.044	18	6.3	9.3	<1.2	0.54	<0.93	<0.68	7.6	0.57	1.1	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
IA2009	02/17/09	370	5.1	0.89	<0.45	3.1	8.9	65	<1.2	<1.1	<0.95	<0.69	25	0.70	34	<0.76	1.0	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	05/13/09	7.4	<0.19	<0.69	<0.045	2.4	5.0	<1.3	<1.2	0.41	<0.95	<0.69	5.4	<0.56	1.0	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	06/08/09	21	0.67	<0.67	<0.043	2.7	14	7.6	<1.2	0.47	<0.92	<0.67	12	0.74	2.3	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	07/08/09	9.7	0.28	<0.68	<0.044	2.1	12	1.6	<1.2	0.41	<0.93	<0.68	12	<0.55	1.4	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	11/20/09	74	1.9	<0.64	<0.041	38	2.8	5.6	<1.1	0.54	<0.88	<0.64	6.4	0.88	2.0	<0.70	<0.70	<0.70	<0.74	<0.97	<0.97	<0.97	<6.0
	12/17/09	28	0.81	<0.65	<0.042	4.9	1.8	1.4	<1.1	0.45	<0.89	<0.65	9.9	<0.52	0.94	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2010	02/17/09	630	3.1	<1.8	<1.1	3.3	7.1	36	<3.1	<2.8	<2.4	<1.8	37	<1.4	99	<1.9	2.4	<1.9	<2.1	<2.7	<2.7	<2.7	<17
	04/27/09	4.4	<0.26	<0.97	<0.062	3.2	4.4	<1.9	<1.7	0.51	<1.3	<0.97	34	1.2	7.4	<1.0	<1.0	<1.0	<1.1	<1.5	<1.5	<1.5	<9.0
	05/13/09	3.6	<0.19	<0.69	<0.045	2.5	3.1	<1.3	<1.2	0.40	<0.95	<0.69	9.4	<0.56	2.0	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	06/08/09	5.0	0.26	<0.68	<0.044	2.4	8.3	2.5	<1.2	0.41	<0.93	<0.68	9.1	0.66	2.6	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	07/08/09	3.9	<0.17	<0.63	<0.040	2.0	5.7	2.5	<1.1	0.45	<0.86	<0.63	7.5	0.63	5.0	<0.69	<0.69	<0.69	<0.73	<0.95	<0.95	<0.95	<5.9
	08/26/09	7.0	0.30	<0.71	<0.046	2.8	6.2	6.3	<1.2	0.50	<0.98	<0.71	30	<0.57	4.7	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	11/20/09	85	2.6	<0.65	<0.042	150	2.7	8.7	<1.1	0.53	<0.89	<0.65	8.7	<0.52	2.4	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
	12/17/09	37	1.3	<0.68	<0.044	5.4	2.0	3.6	<1.2	0.56	<0.93	<0.68	6.8	<0.55	2.2	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
IA2011	02/17/09	2,800	13	<4.5	<2.9	<5.6	<6.4	100	<7.9	<7.2	<6.2	<4.5	200	<3.6	540	<4.9	7.7	<5.0	<5.2	<6.8	<6.8	<6.8	<42
	05/13/09	11	0.23	<0.68	<0.044	2.6	5.9	<1.3	<1.2	0.41	<0.93	<0.68	18	0.61	1.7	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	08/26/09	6.4	0.26	<0.67	<0.043	2.2 J	8.0	5.1	<1.2	0.51	<0.92	<0.67	12	<0.54	3.1	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	11/20/09	58	1.3	<0.68	<0.044	7.2	2.5	1.7	<1.2	0.52	<0.93	<0.68	14	<0.55	1.6	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
IA2013	02/17/09	44	2.8	<0.67	<0.43	2.6	6.2	4.3	<1.2	<1.0	<0.92	<0.67	14	<0.54	9.4	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	08/26/09	<1.1	<0.18	<0.65	<0.042	1.8 J	2.4	<1.2	<1.1	0.49	<0.89	<0.65	10	<0.52	0.74	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2014	02/17/09	32	<0.94	<0.69	<0.45	2.7	7.5	4.0	<1.2	<1.1	<0.95	<0.69	16	0.61	6.2	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	08/26/09	<1.2	<0.19	<0.71	<0.046	2.2 J	12	<1.4	<1.2	0.49	<0.98	<0.71	8.9	<0.57	0.75	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	11/20/09	1.5	1.1	<0.64	<0.041	2.8	4.9	1.5	<1.1	0.55	<0.88	<0.64	6.3	0.90	3.8	<0.70	<0.70	<0.70	<0.74	<0.97	<0.97	<0.97	<6.0
IA2015	02/17/09	72	4.8	<0.63	<0.40	2.6	7.3	4.1	<1.1	<0.99	<0.86	<0.63	22	0.58	15	<0.69	<0.69	<0.69	<0.73	<0.95	<0.95	<0.95	<5.9
	07/08/09	9.4	12	<0.67	<0.043	2.3	19	16	<1.2	0.47	<0.92	<0.67	6.3	<0.54	<0.63	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	07/30/09	<1.2	0.30	<0.69	<0.045	2.2	2.0	<1.3	<1.2	0.42	<0.95	<0.69	9.8	<0.56	<0.66	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	08/26/09	<1.2	<0.20	<0.72	<0.047	1.6 J	2.3	<1.4	<1.3	0.52	<1.0	<0.72	7.2	<0.58	0.86	<0.79	<0.79	<0.79	<0.84	<1.1	<1.1	<1.1	<6.8
	11/20/09	2.0	3.1	<0.68	<0.044	2.6	2.2	1.7	<1.2	0.52	<0.93	<0.68	65	0.78	2.8	2.0	11	2.6	<0.79	<1.0	<1.0	<1.0	<6.3

Table 1
Summary of Indoor and Ambient (Outdoor) Air Sampling Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

SAMPLE LOCATION	ANALYTE / DATE	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl Chloride	Freon 12	Freon 11	Freon 113	Methylene Chloride	Carbon Tetrachloride	1,1,1-Trichloroethane	1,1-Dichloroethene	Acetone	Benzene	Toluene	Ethyl Benzene	m,p-Xylene	o-Xylene	Chlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	1,2,4-Trichlorobenzene
IA2016	02/17/09	44	3.9	<0.84	<0.54	2.9	10	3.4	<1.5	<1.3	<1.2	<0.84	20	<0.68	9.0	<0.92	<0.92	<0.92	<0.98	<1.3	<1.3	<1.3	<7.9
	08/26/09	<1.2	<0.19	<0.71	<0.046	2.6 J	16	<1.4	<1.2	0.53	<0.98	<0.71	22	<0.57	0.77	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
IA2017	02/17/09	55	4.2	<0.69	<0.45	3.4	10	4.0	<1.2	<1.1	<0.95	<0.69	54	0.67	12	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
	07/08/09	<1.1	1.1	<0.67	<0.043	3.2	14	1.6	<1.2	0.45	<0.92	<0.67	15	<0.54	<0.63	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	11/20/09	<1.2	1.4	<0.69	<0.045	3.7	4.8	<1.3	<1.2	0.56	<0.95	<0.69	16	<0.56	<0.66	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
IA2024	02/17/09	42	<0.82	<0.60	<0.39	2.6	16	4.1	<1.0	<0.96	<0.83	<0.60	8.5	0.77	7.0	<0.66	1.0	<0.66	<0.70	<0.91	<0.91	<0.91	<5.6
	08/26/09	8.8	0.50	<0.71	<0.046	2.4 J	31	4.5	<1.2	0.52	<0.98	<0.71	15	<0.57	0.84	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	11/20/09	12	0.73	<0.72	<0.047	4.6	11	3.8	<1.3	0.54	<1.0	<0.72	17	0.90	1.9	<0.79	<0.79	<0.79	<0.84	<1.1	<1.1	<1.1	<6.8
IA2025	04/01/09	140	5.8	<0.71	<0.046	2.3	2.7	58	<1.2	0.40	<0.98	<0.71	11	<0.57	1.2	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	08/26/09	81	4.0	<0.65	<0.042	2.0	12	33	<1.1	0.50	<0.89	<0.65	15	<0.52	4.0	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
	09/29/09	21	0.81	<0.67	<0.043	2.7	4.4	14	<1.2	0.55	<0.92	<0.67	5.6	<0.54	0.84	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	11/20/09	63	2.6	<0.67	<0.043	41	3.4	6.7	<1.2	0.53	<0.92	<0.67	11	0.87	2.1	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	12/17/09	75	1.8	<0.67	<0.043	9.3	1.7	2.2	<1.2	0.56	<0.92	<0.67	13	<0.54	2.1	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
IA2026	04/01/09	95	3.3	<0.68	<0.044	2.6	1.9	33	<1.2	0.43	<0.93	<0.68	5.5	<0.55	1.2	<0.74	0.83	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
IA2027	04/27/09	26	1.4	<0.71	<0.046	3.0	5.5	8.2	<1.2	0.50	<0.98	<0.71	13	0.94	1.3	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
	05/13/09	7.7	0.19	<0.64	<0.041	2.4	5.3	<1.2	<1.1	0.46	<0.88	<0.64	7.5	<0.51	1.0	<0.70	<0.70	<0.70	<0.74	<0.97	<0.97	<0.97	<6.0
	06/08/09	12	1.1	<0.67	<0.043	3.0	13	4.1	1.4	0.46	<0.92	<0.67	15	<0.54	2.6	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
IA2028	04/27/09	<1.1	<0.18	<0.65	<0.042	3.1	3.3	<1.2	<1.1	0.51	<0.89	<0.65	12	0.85	0.99	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
	05/13/09	<1.1	<0.18	<0.65	<0.042	2.6	2.3	<1.2	<1.1	0.45	<0.89	<0.65	6.6	<0.52	<0.62	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2029	04/27/09	2.9	<0.18	<0.65	<0.042	4.7	6.3	1.6	<1.1	0.59	<0.89	<0.65	42	1.4	37	<0.71	1.2	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
IA2030	05/13/09	7.1	0.88	<0.65	<0.042	2.5	9.2	4.7	<1.1	0.44	<0.89	<0.65	9.5	1.8	1.4	<0.71	0.80	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
	06/08/09	2.2	0.31	<0.71	<0.046	2.1	4.3	4.0	<1.2	0.48	<0.98	<0.71	8.3	<0.57	<0.67	<0.78	<0.78	<0.78	<0.82	<1.1	<1.1	<1.1	<6.6
IA2031	05/13/09	4.3	<0.18	<0.67	<0.043	2.6	6.3	<1.3	<1.2	0.41	<0.92	<0.67	9.4	<0.54	1.0	<0.73	<0.73	<0.73	<0.77	<1.0	<1.0	<1.0	<6.2
	06/08/09	20	1.9	<0.69	<0.045	2.7	14	11	<1.2	0.43	<0.95	<0.69	8.6	<0.56	1.2	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
IA2032	05/13/09	25	0.31	<0.65	<0.042	2.8	4.9	<1.2	<1.1	0.41	<0.89	<0.65	14	<0.52	1.4	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
	06/08/09	24	0.77	<0.68	<0.044	2.9	8.0	1.4	<1.2	0.44	<0.93	<0.68	23	0.74	4.3	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	07/08/09	5.3	1.2	<0.72	<0.047	2.8	16	2.3	<1.3	0.41	<1.0	<0.72	6.8	<0.58	1.2	<0.79	<0.79	<0.79	<0.84	<1.1	<1.1	<1.1	<6.8
IA2033	06/08/09	21	0.52	<0.69	<0.045	2.5	4.9	<1.3	<1.2	0.48	<0.95	<0.69	35	0.75	6.5	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
IA2034	07/30/09	<1.2	<0.19	<0.69	<0.045	2.3	2.1	<1.3	<1.2	0.44	<0.95	<0.69	9.7	<0.56	<0.66	<0.76	<0.76	<0.76	<0.80	<1.0	<1.0	<1.0	<6.5
AMBIENT (OUTDOOR) AIR SAMPLE RESULTS		µg/m³																					
AA2012	02/17/09	1.2	<0.88	<0.65	<0.42	2.5	1.6	<1.2	<1.1	<1.0	<0.89	<0.65	7.8	0.56	0.79	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
AA2018	02/17/09	0.98	<0.77	<0.57	<0.37	2.7	1.8	<1.1	<1.0	<0.91	<0.78	<0.57	3.7	0.48	<0.54	<0.62	<0.62	<0.62	<0.66	<0.86	<0.86	<0.86	<5.3
AA2019	02/17/09	<1.0	<0.83	<0.61	<0.40	3.1	2.1	<1.2	<1.1	<0.98	<0.84	<0.61	3.3	0.60	1.1	<0.67	<0.67	<0.67	<0.71	<0.93	<0.93	<0.93	<5.8
AA2020	02/17/09	1.1	<0.83	<0.61	<0.40	2.5	1.8	<1.2	<1.1	<0.98	<0.84	<0.61	9.0	0.57	<0.58	<0.67	<0.67	<0.67	<0.71	<0.93	<0.93	<0.93	<5.8
AA2021	02/17/09	<1.2	<0.92	<0.68	<0.44	2.8	1.6	<1.3	<1.2	<1.1	<0.93	<0.68	7.0	<0.55	<0.64	<0.74	<0.74	<0.74	<0.79	<1.0	<1.0	<1.0	<6.3
	08/26/09	<1.3	<0.20	<0.76	<0.049	1.7 J	<1.1	<1.5	<1.3	0.80	<1.0	<0.76	5.1	<0.61	<0.72	<0.83	<0.83	<0.83	<0.88	<1.1	<1.1	<1.1	<7.1
	11/20/09	2.4	<0.17	<0.61	0.74	3.1	<0.87	<1.2	<1.1	0.67	<0.84	<0.61	5.0	1.0	2.0	<0.67	0.82	<0.67	<0.71	<0.93	<0.93	<0.93	<5.8
AA2022	02/17/09	<1.1	<0.88	<0.65	<0.42	2.6	1.9	<1.2	<1.1	<1.0	<0.89	<0.65	6.8	<0.52	<0.62	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1
AA2023	02/17/09	<1.1	<0.88	<0.65	<0.42	2.5	1.5	<1.2	<1.1	<1.0	<0.89	<0.65	<1.9	<0.52	<0.62	<0.71	<0.71	<0.71	<0.76	<0.99	<0.99	<0.99	<6.1

Notes:
1. Results are presented in units of micrograms per cubic meter (µg/m³). Data are presented to two significant figures.
2. Samples were collected using 6.0-liter Summa® canisters and 8-hour laboratory calibrated flow controllers on the dates indicated. Sample heights for indoor air samples were approximately four to six feet above the floor to target the typical breathing zone. Ambient air samples were collected on the Building 310 roof proximate to air handling unit intakes with the exception of AA2012, which was collected approximately 5 feet above ground surface adjacent to the loading dock on the east side of Building 310. Samples were analyzed by Air Toxics Ltd. of Folsom, California for a list of Site-specific compounds by modified USEPA Method TO-15, Low Level using gas chromatography/mass spectrometry (GC/MS) in full scan mode. For samples collected during and after April 2009, three analytes (vinyl chloride, carbon tetrachloride, and trichloroethene) were analyzed in selective ion monitoring (SIM) mode to achieve lower detection limits.
3. NT - not tested; "<" indicates that an analyte was not detected above the laboratory reporting limit for that sample.
4. "J" indicates an estimated value.

Table 2
Summary of Passive Diffusion Sampling Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

Sample Identification	Sampler Orientation	Start Date_Time	Stop Date_Time	Sample Duration (min)	PCE (µg/m3)	Location Description
PD-1_2008	Down	11/10/08 14:15	11/11/08 16:27	1,572	1,700	Floor Sump
PD-2_2008	Down	11/10/08 14:25	11/11/08 16:32	1,567	940	Cracked Floor Tile
PD-3_2008	Down	11/10/08 14:43	11/11/08 16:30	1,547	9,500	Hole in Concrete Floor
PD-4_2008	Up	11/10/08 14:42	11/11/08 16:31	1,549	<100	Breathing Zone
PD-5_2008	Down	11/10/08 15:35	11/11/08 16:41	1,506	<100	Floor Sample
PD-6_2008	Down	11/10/08 16:49	11/11/08 16:34	1,425	260	Floor Sample
PD-7_2008	Down	11/10/08 16:54	11/11/08 16:40	1,426	<100	Chemical Drain
PD-8_2008	Down	11/10/08 16:56	11/11/08 16:42	1,426	<100	Solvent Drain Line
PD-9_2008	Down	11/10/08 17:04	11/11/08 16:44	1,420	200	Chemical Drain
PD-1_2009	Indoor Air	04/01/09	04/02/09	1,429	540	Breathing Zone
PD-2_2009	Indoor Air	04/01/09	04/02/09	1,431	200	Breathing Zone
PD-3_2009	Down	04/01/09	04/02/09	1,434	330	Floor Sample
PD-4_2009	Down	04/01/09	04/02/09	1,432	<100	Floor Trench
PD-5_2009	Down	04/01/09	04/02/09	1,431	280	Floor Sample
PD-6_2009	Down	04/01/09	04/02/09	1,432	200	Floor Sample
PD-7_2009	Down	04/01/09	04/02/09	1,429	<100	Chemical Drain Line
PD-8_2009	Down	04/01/09	04/02/09	1,426	<100	Floor Sample
PD-9_2009	Down	04/01/09	04/02/09	1,425	<100	Floor Sample
PD-10_2009	Down	04/01/09	04/02/09	1,425	<100	Floor Sample
PD-11_2009	Down	04/01/09	04/02/09	1,422	<100	Floor Sample
PD-12_2009	Down	04/01/09	04/02/09	1,422	1,900	Floor Trench
PD-13_2009	Down	04/01/09	04/02/09	1,420	<100	Floor Sample
PD-14_2009	Down	04/01/09	04/02/09	1,419	<100	Floor Sample
PD-15_2009	Down	04/01/09	04/02/09	1,420	<100	Floor Sample
PD-16_2009	Down	04/01/09	04/02/09	1,418	<100	Floor Sample
PD-17_2009	Down	04/01/09	04/02/09	1,417	<100	Floor Trench
PD-18_2009	Down	04/01/09	04/02/09	1,380	<100	Chemical Drain Line
PD-20_2009	Down	04/01/09	04/02/09	1,376	<100	Floor Sample
PD-21_2009	Down	05/13/09 7:18	05/14/09 7:18	1,440	2,200	Chemical Drain
PD-22_2009	Up	05/13/09 7:20	05/14/09 7:20	1,440	<100	Chemical Drain
PD-23_2009	Down	05/13/09 7:30	05/14/09 7:28	1,438	<100	Floor Sump
PD-24_2009	Down	05/13/09 7:24	05/14/09 7:22	1,438	2,000	Chemical Drain
PD-25_2009	Up	05/13/09 7:26	05/14/09 7:24	1,438	410	Chemical Drain
PD-26_2009	Down	05/13/09 7:36	05/14/09 7:36	1,440	1,100	Chemical Drain
PD-27_2009	Up	05/13/09 7:38	05/14/09 7:38	1,440	<100	Chemical Drain
PD-28_2009	Indoor Air	05/13/09 7:50	05/14/09 7:46	1,436	<100	Breathing Zone
PD-29_2009	Down	05/13/09 7:42	05/14/09 7:42	1,440	100	Chemical Drain
PD-30_2009	Up	05/13/09 7:44	05/14/09 7:44	1,440	<100	Chemical Drain
PD-31_2009	Down	05/13/09 8:02	05/14/09 7:52	1,430	2,800	Chemical Drain
PD-32_2009	Up	05/13/09 8:04	05/14/09 7:54	1,430	<100	Chemical Drain
PD-33_2009	Down	05/13/09 8:15	05/14/09 7:57	1,422	<100	Raised Floor
PD-34_2009	Up	05/13/09 8:17	05/14/09 7:58	1,421	<100	Raised Floor

Table 2
Summary of Passive Diffusion Sampling Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

Sample Identification	Sampler Orientation	Start Date_Time	Stop Date_Time	Sample Duration (min)	PCE (µg/m3)	Location Description
PD-35_2009	Down	05/13/09 8:20	05/14/09 8:00	1,420	<100	Cracked Tile Near Floor Sump
PD-36_2009	Up	05/13/09 8:22	05/14/09 8:01	1,419	<100	Cracked Tile Near Floor Sump
PD-37_2009	Down	05/13/09 8:26	05/14/09 8:03	1,417	290	Cracked Floor Tile
PD-38_2009	Up	05/13/09 8:28	05/14/09 8:04	1,416	<100	Cracked Floor Tile
PD-39_2009	Indoor Air	05/13/09 8:42	05/14/09 8:10	1,408	<100	Breathing Zone
PD-40_2009	Down	05/13/09 9:00	05/14/09 8:20	1,400	<100	Open Panel in Raised Floor
PD-41_2009	Up	05/13/09 9:02	05/14/09 8:22	1,400	<100	Open Panel in Raised Floor
PD-42_2009	Down	05/13/09 8:57	05/14/09 8:17	1,400	<100	Floor Sump
PD-43_2009	Indoor Air	05/13/09 8:36	05/14/09 8:08	1,412	<100	Breathing Zone
PD-44_2009	Down	05/13/09 9:56	05/14/09 9:05	1,389	<100	Under Raised Floor
PD-45_2009	Up	05/13/09 9:58	05/14/09 9:07	1,389	<100	Under Raised Floor
PD-46_2009	Down	05/13/09 9:50	05/14/09 9:00	1,390	<100	Cracked Floor Tile
PD-47_2009	Up	05/13/09 9:52	05/14/09 9:01	1,389	<100	Cracked Floor Tile
PD-48_2009	Indoor Air	05/13/09 9:46	05/14/09 8:58	1,392	<100	Breathing Zone
PD-49_2009	Down	05/13/09 9:24	05/14/09 8:34	1,390	920	Edge of Floor Sump
PD-50_2009	Up	05/13/09 9:26	05/14/09 8:36	1,390	200	Edge of Floor Sump
PD-51_2009	Down	05/13/09 9:28	05/14/09 8:39	1,391	2,200	Floor Sump
PD-52_2009	Up	05/13/09 9:30	05/14/09 8:41	1,391	1,200	Floor Sump
PD-53_2009	Down	05/13/09 9:32	05/14/09 8:43	1,391	1,400	Floor Sump
PD-54_2009	Up	05/13/09 9:34	05/14/09 8:45	1,391	3,200	Floor Sump
PD-55_2009	Down	05/13/09 9:36	05/14/09 8:47	1,391	<100	Floor Sump
PD-56_2009	Up	05/13/09 9:38	05/14/09 8:48	1,390	<100	Floor Sump
PD-57_2009	Down	05/13/09 9:40	05/14/09 8:55	1,395	890	Edge of Floor Sump
PD-58_2009	Up	05/13/09 9:42	05/14/09 8:57	1,395	<100	Edge of Floor Sump

Notes:
1. Passive diffusion (PD) samples were collected using 3M 3500 sample devices (i.e., badges). Samples were analyzed for tetrachloroethylene (PCE) using a modified NIOSH Method 1003 by Galson Laboratories of East Syracuse, New York. Results are presented in units of micrograms per cubic meter ($\mu g/m^3$). Data are presented to two significant figures.
2. "<" indicates that PCE was not detected above the laboratory method detection limit for that sample.
3. The sample year was added to the sample identification to differentiate between PD samples with similar sample names.
4. The sampler orientation is provided to identify the placement of the PD sampler during sampling activities. "Down" indicates that the PD sampler was placed face down on the targeted surface (e.g., floor or sump), "Up" indicates that the PD sampler was placed face up at the targeted surface level (e.g., floor or sump), and "Indoor Air" indicates that the PD sampler was placed within the breathing zone. PD sampler locations relative to building features are presented on Figure 8 of this report.

Table 3
Summary of Subslab Vapor Sample Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

Sample Location	**SS-01**		**SS-02**		**SS-03**		**SS-04**	**SS-05**		**SS-06**		**SS-07**		**SS-08**	
Sample Type	**SSV**	**EXTRACT**	**SSV**	**EXTRACT**	**SSV**	**EXTRACT**	**SSV**	**SSV**	**EXTRACT**	**SSV**	**EXTRACT**	**SSV**	**EXTRACT**	**SSV**	**EXTRACT**
Date	05/05/09	05/06/09	05/05/09	05/06/09	05/05/09	05/06/09	05/05/09	05/06/09	05/07/09	05/06/09	05/07/09	05/06/09	05/06/09	05/05/09	05/07/09
Analyte	$\mu g/m^3$														
Tetrachloroethene	270,000	260,000	80,000	28,000	190	110	150,000	140,000	100,000	1,000,000	770,000	1,100	4,500	980,000	2,800,000
Trichloroethene	66,000	70,000	3,600	1,400	140	190	59,000	10,000	5,700	24,000	24,000	96	2,200	60,000	160,000
cis-1,2-Dichloroethene	2,400	3,000	550	210	<5.2	<4.8	1,900	380	<340	1,600	2,100	<5.0	15	6,500	15,000
Vinyl Chloride	<210	<420	<37	<42	<3.4	<3.1	<75	<64	<220	<630	<410	<3.2	<9.4	<480	<1,600
Freon 12	1,700	<810	<72	<82	<6.5	<6.0	1,200	<120	<420	<1,200	<790	<6.2	<18	1,100	<3,100
Freon 11	1,300	1,400	<82	<93	<7.4	<6.8	1,300	<140	<470	<1,400	1,100	<7.1	24	<1,000	<3,500
Freon 113	260,000	240,000	2,300	1,100	<10	1,400	170,000	470	<650	260,000	250,000	100	4,900	170,000	910,000
Methylene Chloride	340	<570	<51	<57	<4.6	<4.2	<100	<88	<290	<860	<550	<4.4	<13	<650	<2,200
Carbon Tetrachloride	<530	<1,000	<92	<100	<8.3	<7.7	<180	<160	<530	<1,600	<1000	<8.0	<23	<1,200	<3,900
1,1,1-Trichloroethane	<460	<890	<80	<90	<7.2	<6.6	230	<140	<460	<1,300	<870	<6.9	71	<1,000	<3,400
1,1-Dichloroethene	910	<650	<58	<66	<5.2	<4.8	680	<100	<340	<980	<630	<5.0	<14	<750	<2,500
Acetone	<800	<1,600	470	<160	390	34	1,600	<240	<800	<2,300	<1500	480	<35	1,900	<5,900
Benzene	<270	<520	<47	<53	7.1	<3.9	<93	<80	<270	<790	<510	<4.0	<12	<600	<2,000
Toluene	<320	<620	140	<62	140	<4.6	310	<95	<320	<930	<600	57	<14	<710	<2,400
Ethyl Benzene	<360	<710	<64	<72	6.5	<5.3	<130	<110	<370	<1,100	<690	<5.5	<16	<820	<2,700
m,p-Xylene	<360	<710	<64	<72	22	<5.3	<130	<110	<370	<1,100	<690	<5.5	<16	<820	<2,700
o-Xylene	<360	<710	<64	<72	9.9	<5.3	<130	<110	<370	<1,100	<690	<5.5	<16	<820	<2,700
Chlorobenzene	<390	<760	<67	<76	<6.1	<5.6	<130	<120	<390	<1100	<730	<5.8	<17	<870	<2,900
1,3-Dichlorobenzene	<500	<990	<88	<100	<7.9	<7.3	<180	<150	<510	<1,500	<960	<7.6	<22	<1,100	<3,800
1,4-Dichlorobenzene	<500	<990	<88	<100	<7.9	<7.3	<180	<150	<510	<1,500	<960	<7.6	<22	<1,100	<3,800
1,2-Dichlorobenzene	<500	<990	<88	<100	<7.9	<7.3	<180	<150	<510	<1,500	<960	<7.6	<22	<1,100	<3,800
1,2,4-Trichlorobenzene	<2,500	<4,900	<430	<490	<39	<36	<870	<750	<2,500	<7,300	<4700	<38	<110	<5,600	<18,000
Total VOCs:	600,000	570,000	87,000	31,000	910	1,700	390,000	150,000	110,000	1,300,000	1,000,000	1,800	12,000	1,200,000	3,900,000

Notes:
1. Results are presented in units of micrograms per cubic meter ($\mu g/m^3$). Data are presented to two significant figures
2. The sample type indicates whether the subslab vapor sample was collected prior to integrity testing/extraction testing ("SSV") or during extraction testing ("EXTRACT"). The SSV samples were collected using 1.0-liter Summa® canisters and 1-hour laboratory flow controllers. The "EXTRACT" samples were collected just prior to the completion of extraction testing at locations SS-01 through SS-10, by collecting a grab subslab vapor sample into a 1.0-liter Summa® canister through a Swagelok® valve installed on the extraction testing equipment manifold. No post-extraction sample was collected at SS-04 due to observed flooding of the extraction port during extraction testing.
3. Samples were analyzed by Air Toxics Ltd. of Folsom, California for a list of Site-specific compounds by modified USEPA Method TO-15.
4. "<" indicates that an analyte was not detected above the laboratory reporting limit for that sample.
5. Sample locations SS-01 through SS-10 were installed as subslab vapor extraction ports. Sample locations SS-11 through SS-22 were installed as subslab vapor monitoring ports.
6. A discrepancy between shipped vacuum and received vacuum for the SS-10 EXTRACT Summa® canister may have resulted in the dilution of the sample prior to analysis.

Table 3
Summary of Subslab Vapor Sample Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

Sample Location	**SS-09**			**SS-10**		**SS-11**	**SS-12**	**SS-13**	**SS-14**	**SS-15**	**SS-16**	**SS-17**	**SS-18**	**SS-19**	**SS-20**	**SS-21**	**SS-22**
Sample Type	**SSV**	**SSV**	**EXTRACT**	**SSV**	**EXTRACT**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**	**SSV**
Date	05/06/09	5/6/2009 Duplicate	05/07/09	05/06/09	05/07/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09	05/06/09
Analyte	$\mu g/m^3$																
Tetrachloroethene	1,100	1,200	55	11,000	9,400	890	310	15,000	1,700	250	3,100	110,000	270	2,100	280,000	56,000	240,000
Trichloroethene	61	78	51	1,200	1,000	1,000	130	570	230	120	870	20,000	14	280	9,100	37,000	9,200
cis-1,2-Dichloroethene	<4.8	<5.2	<5.1	<41	27	<5.0	<5.1	<45	<10	<4.6	450	7,100	<4.8	<5.1	<430	<200	<470
Vinyl Chloride	<3.1	<3.4	<3.3	<26	<18	<3.2	<3.3	<29	<6.7	<3.0	<24	<260	<3.1	<3.3	<280	<130	<300
Freon 12	20	29	30	<51	<34	910	<6.4	<57	<13	<5.8	<46	<500	<6.0	<6.4	<530	<240	<590
Freon 11	<6.8	<7.4	<7.3	<58	<38	55	15	<64	<15	18	350	3,100	<6.8	<7.3	<610	<280	1,500
Freon 113	<9.3	<10	<9.9	240	390	46	32	15,000	430	<8.9	19,000	270,000	<9.3	230	21,000	73,000	200,000
Methylene Chloride	<4.2	<4.6	<4.5	<36	<24	<4.4	<4.5	<40	26	<4.0	<33	<350	<4.2	<4.5	<380	<170	<410
Carbon Tetrachloride	<7.6	<8.3	<8.1	<65	<43	<8.0	<8.1	<72	<16	<7.3	<59	<640	<7.6	<8.1	<680	<310	<750
1,1,1-Trichloroethane	<6.6	<7.2	<7.1	<56	<37	<6.9	<7.0	<62	<14	<6.4	<51	<560	<6.6	<7.1	<590	3,200	<650
1,1-Dichloroethene	<4.8	<5.2	<5.1	<41	<27	<5.0	<5.1	<45	<10	<4.6	54	1,300	<4.8	<5.1	<430	<200	<470
Acetone	370	450	<12	810	<65	240	170	<110	84	40	<89	1,500	82	25	<1,000	2,500	<1,100
Benzene	7.0	8.4	<4.1	<33	<22	<4.0	<4.1	<36	<8.4	<3.7	<30	<320	<3.9	<4.1	<340	<160	<380
Toluene	33	38	<4.9	<39	<26	34	<4.9	<43	<9.9	<4.4	<35	<380	<4.6	<4.9	<410	<190	<450
Ethyl Benzene	<5.2	<5.7	<5.6	<45	<30	<5.5	<5.6	<50	<11	<5.0	<41	<440	<5.2	<5.6	<470	<210	<520
m,p-Xylene	14	17	<5.6	<45	<30	<5.5	<5.6	<50	<11	<5.0	<41	<440	<5.2	<5.6	<470	<210	<520
o-Xylene	6.0	7.4	<5.6	<45	<30	<5.5	<5.6	<50	<11	<5.0	<41	<440	<5.2	<5.6	<470	<210	<520
Chlorobenzene	<5.6	<6.1	<6.0	<47	<32	<5.8	<5.9	<53	<12	<5.4	<43	<470	<5.6	<6.0	<500	<230	<550
1,3-Dichlorobenzene	<7.3	<7.9	<7.8	<62	<41	<7.6	<7.8	<69	<16	<7.0	<56	<610	<7.3	<7.8	<650	<300	<720
1,4-Dichlorobenzene	<7.3	<7.9	<7.8	<62	<41	<7.6	<7.8	<69	<16	<7.0	<56	<610	<7.3	<7.8	<650	<300	<720
1,2-Dichlorobenzene	<7.3	<7.9	<7.8	<62	<41	<7.6	<7.8	<69	<16	<7.0	<56	<610	<7.3	<7.8	<650	<300	<720
1,2,4-Trichlorobenzene	<36	<39	<38	<300	<200	<38	<38	<340	<78	<34	<280	<3,000	<36	<38	<3,200	<1,500	<3,500
Total VOCs:	1,600	1,800	140	13,000	11,000	3,200	660	31,000	2,500	430	24,000	410,000	370	2,600	310,000	170,000	450,000

Notes:
1. Results are presented in units of micrograms per cubic meter ($\mu g/m^3$). Data are presented to two significant figures
2. The sample type indicates whether the subslab vapor sample was collected prior to integrity testing/extraction testing ("SSV") or during extraction testing ("EXTRACT"). The SSV samples were collected using 1.0-liter Summa® canisters and 1-hour laboratory flow controllers. The "EXTRACT" samples were collected just prior to the completion of extraction testing at locations SS-01 through SS-10, by collecting a grab subslab vapor sample into a 1.0-liter Summa® canister through a Swagelok® valve installed on the extraction testing equipment manifold. No post-extraction sample was collected at SS-04 due to observed flooding of the extraction port during extraction testing.
3. Samples were analyzed by Air Toxics Ltd. of Folsom, California for a list of Site-specific compounds by modified USEPA Method TO-15.
4. "<" indicates that an analyte was not detected above the laboratory reporting limit for that sample.
5. Sample locations SS-01 through SS-10 were installed as subslab vapor extraction ports. Sample locations SS-11 through SS-22 were installed as subslab vapor monitoring ports.
6. A discrepancy between shipped vacuum and received vacuum for the SS-10 EXTRACT Summa® canister may have resulted in the dilution of the sample prior to analysis.

Table 4
Summary of Concrete and Soil Sample Data
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

LOCATION	SS-01		SS-02		SS-03		SS-04		SS-05		SS-06				SS-07		SS-08		SS-09		SS-10	
SAMPLE ID/MEDIA	C01 Concrete	C01 Soil	C02 Concrete	C02 Soil	C03 Concrete	C03 Soil	C04 Concrete	C04 Soil	C05 Concrete	C05 Soil	C06 Concrete	Dup Concrete	C06 Soil	Dup Soil	C07 Concrete	C07 Soil	C08 Concrete	C08 Soil	C09 Concrete	C09 Soil	C10 Concrete	C10 Soil
ANALYTE	µg/kg																					
Tetrachloroethene	<5	30	39	38	<5	<5	<5	66	<5	81	13	25	120	310	<5	<5	20	570	<5	<5	<5	950
Trichloroethene	<5	11	<5	<5	<5	<5	<5	29	<5	8	<5	<5	7	<250	<5	<5	<5	24	<5	<5	<5	<250
cis-1,2-Dichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<250	<5	<5	<5	5	<5	<5	<5	<250
Acetone	<200	<200	<200	<200	<200	<200	430	<200	<200	<200	<200	<200	<200	<2500	<200	<200	3,300	<210	<210	<200	<200	<2,500
Toluene	<5	<5	<5	<5	<5	<5	<5	<5	10	<5	<5	<5	<5	<250	<5	<5	<5	<5	<5	<5	<5	<250

Notes:
1. Sample results are presented in units of micrograms per kilogram (µg/kg).
2. Concrete samples were collected by crushing approximately 2-inches from the top section (i.e., just below the floor surface) of the concrete core removed during the installation of each subslab vapor extraction port. Soil samples were collected with a Geoprobe® hand-probe kit using a two foot macrocore sampler. Samples were collected on May 4, 2009 and were analyzed for a Site-specific list of volatile organic compounds (VOCs) using USEPA Method 8260B by Groundwater Analytical of Buzzards Bay, Massachusetts.
3. "<" indicates that an analyte was not detected above the laboratory reporting limit for that sample.
4. Only VOCs that were detected in at least one sample are shown in the table.

Table 5
Summary of HVAC Modifications and Results
Building 310 VOC Source Investigation
IBM East Fishkill Facility

Area Description						Before HVAC Modifications				After HVAC Modifications			
Location	Nearest Column	Sample ID	Floor Area (ft^2)	Ceiling Height (ft)	Room Volume (ft^3)	Air Flow (ft^3/min)	HVAC Unit	Air Changes per Hour (ACH, hr^{-1})	PCE (ug/m^3)	Air Flow (ft^3/min)	HVAC Unit	Air Changes per Hour (ACH, hr^{-1})	Final PCE (ug/m^3)
Computer storage room[2]	C-12	IA-2011			13,250	Negligible	None	0.01 (estimated)	2800	210	Exhaust fan C-11	13	58
			800	10						1,200	Transfer fan TF-2		
			350	15						1,750	Transfer fan TF-3		
Maintenance shop office	F-12	IA-2010	880	10	8,800	140	AC-32: OA damper at 20%	1.0	630	1,000	AC-32: OA damper at 100%	6.8	37
Storage room	B-22	IA-2015	1,600	10	16,000	82	AC-30: OA damper at 20%; supply duct from RCU-1 at 25%	0.31	72	670	AC-30: OA damper at 80%; supply duct from RCU-1 at 25%	2.5	2
Jig grind tool shop	B-22	IA-2034	1,600	10	16,000	240	AC-30: OA damper at 20%; supply duct from RCU-1 at 75%	0.90	Not Sampled	1,970	AC-30: OA damper at 80%; supply duct from RCU-1 at 75%	7.4	<1.2
North MER[2]	C-11	IA-2025	4,800	15	72,000	2,100	Exhaust fan B-10	8.1	140	2,100	Exhaust fan B-10	7	75
						7,600	Exhaust fan B-11			0	Exhaust fan B-11		
										8,200	Transfer fan TF-1		
										0	Transfer fan TF-1B		
DI water room	R-7	IA-2006	1,800	15	27,000	Negligible	None	0.01 (estimated)	67/55	1,400	New supply duct from AC-4	3.1	38
Zone AC-15	F-3	IA-2002	26,000	10	260,000	5,000	AC-15: OA damper at 25%	1.2	13	10,000	AC-15: OA damper at 50%	2.3	4.6

Notes:
1. HVAC air flow rates and damper positions were provided by IBM Facilities Engineering.
2. In the storage room at column C-12 and the North MER, the ACH refers to internal air exchange calculated from the flow rates of either the exhaust fans or transfer fans.

FIGURES

APPENDIX A

Limitations

Appendix A
SHPC Limitations

1. The findings and conclusions described in this report are based in part on the data obtained from a finite number of samples from widely spaced locations. The figures are intended to depict inferred conditions during a given period of time, consistent with available information. The actual conditions will vary from that shown, both spatially and temporally. Other interpretations are possible. The nature and extent of variations between sampling locations may not become evident until further investigation is initiated. If variations or other latent conditions then appear evident, it may be necessary to re-evaluate the conclusions of this report.

2. The conclusions contained in this report are based in part upon various types of chemical data as well as historical and hydrogeologic information developed by previous investigators. While SHPC has reviewed that data available to us at the time the report was prepared and information as stated in this report, any of SHPC's interpretations and conclusions that have relied on that information will be contingent on its validity. SHPC has not performed an independent assessment of the reliability of the data; should additional chemical data, historical information, or hydrogeologic information become available in the future, such information should be reviewed by SHPC and the interpretations and conclusions presented herein may be modified accordingly.

3. Sampling and quantitative laboratory testing was performed by others as part of the investigation as noted within the report. Where such analyses have been conducted by an outside laboratory, unless otherwise stated in the report, SHPC has relied upon the data provided, and has not conducted an independent evaluation of the reliability of these data. It must be noted that additional compounds not searched for during the current study may be present in vapor and groundwater at the site. Moreover, it should be noted that variations in the types and concentrations of contaminants and variations in their distribution within the groundwater and vapor may occur due to the passage of time, seasonal water table fluctuations, recharge events, and other factors.

4. This report has been prepared for the exclusive use of the IBM Corporation for specific application to the IBM East Fishkill facility in accordance with generally accepted hydrogeologic and engineering practices. No warranty, expressed or implied, is made. The contents of this report should not be relied on by any other party without the express written consent of SHPC.

5. In preparing this report, SHPC has endeavored to conform to generally accepted practices of other consultants undertaking similar studies at the same time and in the same geographical area. SHPC has attempted to observe a degree of care and skill generally exercised by the technical community under similar circumstances and conditions.

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APPENDIX B

Calculations

APPENDIX B
CALCULATIONS

Refer to Section 3.5.2 of the report text for the context of these calculations.

Calculation 1

Assuming a Henry's law value of H = 0.579 (dimensionless) for PCE at 20ºC (source: http://www.epa.gov/athens/learn2model/part-two/onsite/esthenry.htm), the aqueous-phase concentration of PCE in equilibrium with the vapor phase concentration is expressed as

$$C_{aq}\ [ug/L] = C_{vapor}\ [ug/m^3] / (H * 1000\ L/m^3)$$

$$= 1{,}000{,}000\ ug/m^3 / (0.579 * 1000)$$

$$C_{aq} = 1{,}700\ ug/L$$

Calculation 2

Mass flux is approximated by

$$J\ [\mu g/m^2/hr] = D_e\ [cm^2/s] * (C_{subslab} - C_{indoor})[\ \mu g/m^3] / L\ [m] * (1\ m^2/10000\ cm^2) * (3600\ s/hr)$$

where:

D_e = effective diffusion coefficient of PCE through concrete
$= D_{air} * (\theta_a)^{3.33} / (\theta_T)^2$

and

$D_{air} = 7.85 \times 10^{-2}\ cm^2/s$ (free air diffusion coefficient for PCE)
$\theta_a = 0.05$ (air filled porosity of $\theta_a = 0.05$ as a fraction of the bulk volume)
$\theta_T = 0.1$ (concrete total porosity)

Thus,

$$D_e = (7.85 \times 10^{-2}\ cm^2/s)(0.05)^{3.33}/(0.1)^2 = 3.6 \times 10^{-4}\ cm^2/s$$

Assuming
$C_{subslab} = 1{,}000{,}000\ \mu g/m^3$
$C_{indoor} = 300\ \mu g/m^3$, and
L = slab thickness = 0.15 m

then

$$J = (3.6 \times 10^{-4}\ cm^2/s)*(1{,}000{,}000\ \mu g/m^3 - 300\ \mu g/m^3)/(0.15m)*(1m^2/10000cm^2)*(3600\ s/hr)$$
$$J = 860\ \mu g/m^2/hr$$

Calculation 3

Under steady-state conditions for a given room volume, mass in = mass out, and

$$J * A = C_{indoor} * V * (Q/V)$$

Substituting for V

$$V = A * H$$

and

$$(Q/V) = ACH \text{ (air changes per hour)}$$

then the above equation becomes

$$J = C_{indoor} * H * ACH,$$

or rearranging,

$$C_{indoor} = J/(H * ACH)$$

$$C_{indoor} = (860\ \mu g/m^2/hr)/(3m * 1/hr)$$

$$C_{indoor} == 300\ \mu g/m^3$$

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APPENDIX C

Source Assessment Field Forms and Documentation

Concrete & Soil Sampling Summary

SHA IMPROVING EARTH	Project No.: 2999.00/020	Date: 05/04/2009
	Project Name: IBM-EF	
	Building/Location: 310 / Mechanical Room	
Meters Used: 15g Methanol 5g $NaHSO_2$ 10g solid/no preservative	Project Manager: DS/CGL	
	Collector(s): CGL/MTS	

SAMPLING INFORMATION

Sample ID	C01 Concrete	C01 Soil	C02 Concrete	C02 Soil	C03 Concrete	C03 Soil
Date/Time	5/4/09 9:45	5/4/09 9:55	5/4/09 10:20	5/4/09 10:30	5/4/09 11:15	5/4/09 11:10
Sample Depth BGS	0 - 3"	1 - 1.5'	1 - 2"	1 - 1.5'	1 - 3"	1.1 - 1.6'
Depth of concrete (ft.)	1.0	-	1.0	-	1.1	-
PID (ppmv)	2.0	0.2	2.4	1.5	3.5	1.7
Sample Penetration (ft.)	-	1.0 - 3.0	-	1.0 - 3.0	-	1.1 - 3.1
Sample Recovery (ft.)	-	1.8	-	1.0		0.9
Geologic Description	-	Brown, fine to coarse SAND, little Silt, trace Gravel. Dry	-	Brown, fine to coarse SAND, some Silt, trace Gravel. Moist		Orangish-brown, fine to coarse SAND, some Silt, trace Gravel. Dry

OTHER SAMPLING INFORMATION

Story / Level	-	-	-	-	-	-
Gap between Slab & Soil	1/4 - 0.5"	-	1/4 - 0.5"	-	0.5 - 1"	-
Indoor Air Temp (°F)						
Noticeable Odor?						
Comment Number						

COMMENTS

Concrete & Soil Sampling Summary

SHA IMPROVING EARTH	Project No.: 2999.00/020	Date: 05/04/2009	
	Project Name: IBM-EF		
	Building/Location: 310 / Mechanical Room		
Meters Used: 15g Methanol 5g $NaHS0_2$ 10g solid/no preservative	Project Manager: DS/CGL		
	Collector(s): CGL/MTS		

SAMPLING INFORMATION

Sample ID	C08 Concrete	C08 Soil	C04 Concrete	C04 Soil	C09 Concrete	C09 Soil
Date/Time	5/4/09 11:50	5/4/09 11:50	5/4/09 12:15	5/4/09 12:20	5/4/09 13:40	5/4/09 13:45
Sample Depth BGS	1 - 3"	0.4 - 0.9'	1 - 3"	0.4 - 1.2'	1 - 3"	0.6 - 1.1'
Depth of concrete (ft.)	0.4	-	0.4	-	0.6	-
PID (ppmv)	23.1	1.5	10.5	2.7	1.7	1.0
Sample Penetration (ft.)	-	0.4 - 2.1 (to refusal)	-	0.4 - 1.2 (to refusal)	-	0.6 - 2.6
Sample Recovery (ft.)	-	0.8	-	0.3		1.1
Geologic Description	-	Brown, fine to coarse SAND, some Silt, trace Gravel. Dry	-	Brown, fine to coarse SAND, little Silt, trace Gravel. Dry		Brown, fine to coarse SAND, little Silt, trace Gravel. Dry

OTHER SAMPLING INFORMATION

Story / Level	-	-	-	-	-	-
Gap between Slab & Soil	1/4 - 1/2"	-	$\leq$ 1/8"	-	$\leq$ 1/8"	-
Indoor Air Temp (°F)						
Noticeable Odor?						
Comment Number						

COMMENTS

Concrete & Soil Sampling Summary

SHA IMPROVING EARTH

Project No.: 2999.00/020	Date: 05/04/2009
Project Name: IBM-EF	
Building/Location: 310 / Mechanical Room	
Meters Used: 15g Methanol 5g $NaHS0_2$ 10g solid/no preservative	Project Manager: DS/CGL Collector(s): CGL/MTS

SAMPLING INFORMATION

Sample ID	C05 Concrete	C05 Soil	C10 Concrete	C10 Soil	C07 Concrete	C07 Soil
Date/Time	5/4/09 14:15	5/4/09 14:15	5/4/09 15:10	5/4/09 15:15	5/4/09 15:50	5/4/09 16:05
Sample Depth BGS	2 - 3"	0.5 - 1 '	1 - 2"	0.5 - 1'	1 - 3"	0.5 - 1'
Depth of concrete (ft.)	0.5	-	0.5	-	0.45	-
PID (ppmv)	1.9	2.5	2.6	1.7	2.6	2.1
Sample Penetration (ft.)	-	0.5 - 2.5	-	0.5 - 2.5	-	0.5 - 1 (to refusal)
Sample Recovery (ft.)	-	1.4	-	1.0	-	0.4
Geologic Description	-	Brown, fine to coarse SAND, some Silt, trace Gravel. Dry	-	Brown, fine to coarse SAND, some Silt, trace Gravel. Dry		Brown, fine to coarse SAND, little Silt, trace Gravel. Dry

OTHER SAMPLING INFORMATION

Story / Level	-	-	-	-	-	-
Gap between Slab & Soil	1/8 - 1/4"	-	$\leq$ 1/8"	-	1/8 - 1/4"	-
Indoor Air Temp (°F)						
Noticeable Odor?						
Comment Number						

COMMENTS

Concrete & Soil Sampling Summary

SHA IMPROVING EARTH	Project No.: 2999.00/020	Date: 05/04/2009
	Project Name: IBM-EF	
	Building/Location: 310 / Mechanical Room	
Meters Used: 15g Methanol 5g $NaHS0_2$ 10g solid/no preservative	Project Manager: DS/CGL	
	Collector(s): CGL/MTS	

SAMPLING INFORMATION

Sample ID	C06 Concrete	C06 Soil				
Date/Time	5/4/09 16:20	5/4/09 16:30				
Sample Depth BGS	2 - 4"	0.7 - 1.2'				
Depth of concrete (ft.)	0.7'	-				
PID (ppmv)	ND	1.1				
Sample Penetration (ft.)	-	0.7 - 2.7				
Sample Recovery (ft.)	-	1.2				
Geologic Description	-	Brown, fine to coarse SAND, little Silt, trace Gravel. Dry				

OTHER SAMPLING INFORMATION

Story / Level	-	-				
Gap between Slab & Soil	1/4 - 1/ 2"	-				
Indoor Air Temp (°F)						
Noticeable Odor?						
Comment Number	1	1				

COMMENTS

1. Duplicate concrete and duplicate soil samples were collected at sample locations C06 Concrete & C06 Soil, respectively. Date = 5/4/09, Time = NT

Subslab Monitoring Point Integrity Testing Summary

SHA IMPROVING EARTH	Project No.:	2999.00/020	Date:	5/6-7/09
	Project Name:	IBM-EF B310 Source Investigation		
	Location:	Hopewell Junction, New York		
	Project Manager:	CGL		

Collector (s):	PRM, SAW
O_2 / CH_4 / CO_2 Meter Used:	GEM 2000 (Pine)
PID Meter Used:	MiniRae 2000 (Pine)
FID Meter Used:	-
He Meter:	Dielectric (Pine)
Other:	-

INTEGRITY TESTING RECORD

Location No.	**SS-01**	**SS-02**	**SS-03**	**SS-04**	**SS-05**
Performance Testing					
Vacuum (in H_20)	0.1	0.15	0.05	3.00	1.6
Time to fill 1 liter Bag	5:00	5:00	4:00	5:00	5:00
Approx. Flow Rate (L/min)	0.20	0.20	0.25	0.20	0.20
Tracer Gas Applied?	He	He	He	He	He
Tracer Gas Concentration (ppmv)	0	0	0	0	0
O_2 (%)	19.1	20.7	21.6	20.8	18.2
CH_4 (%)	1.5	0.4	0.0	0.0	0.6
CO_2 (%)	3.8	2.2	0.5	0.5	4.2
PID (ppmv)	70.9	75.0	50.5	47.9	142
Pre-Test Pressure (in wc)	0.019	0.007	0.017	0.000	0.000
Testing Date and Time	05/07/09 15:15	05/07/09 14:59	05/06/09 19:21	5/6/109 19:11	05/07/09 16:11
Screen Interval Depth (ft bgs)	1.0	1.0	1.1	0.4	0.5
Ambient Air Temp (°F)	75° F	75° F	75° F	68° F	68° F
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
Comment No.	1	1	1	1	1

COMMENTS

1. Pre-test pressure readings collected on 5/6/09.

Subslab Monitoring Point Integrity Testing Summary

SHA IMPROVING EARTH	Project No.:	2999.00/020	Date:	5/6-7/09
	Project Name:	IBM-EF B310 Source Investigation		
	Location:	Hopewell Junction, New York		
	Project Manager:	CGL		

Collector (s):	PRM, SAW
O_2 / CH_4 / CO_2 Meter Used:	GEM 2000 (Pine)
PID Meter Used:	MiniRae 2000 (Pine)
FID Meter Used:	-
He Meter:	Dielectric (Pine)
Other:	-

INTEGRITY TESTING RECORD

Location No.	**SS-06**	**SS-07**	**SS-08**	**SS-09**	**SS-10**
Performance Testing					
Vacuum (in $H_2 0$)	0.45	0.05	0.05	0.35	1.1
Time to fill 1 liter Bag	5:00	5:00	5:00	5:00	5:00
Approx. Flow Rate (L/min)	0.20	0.20	0.20	0.20	0.20
Tracer Gas Applied?	He	He	He	He	He
Tracer Gas Concentration (ppmv)	50	0	0	25	0
O_2 (%)	19.7	20.3	18.5	21.7	20.5
CH_4 (%)	0.2	0.5	1.0	0.0	0.3
CO_2 (%)	2.2	2.4	2.8	0.4	2.1
PID (ppmv)	55.0	18.0	298	30.5	17.5
Pre-Test Pressure (in wc)	NM	0.000	-0.003	0.000	0.000
Testing Date and Time	05/07/09 14:49	05/07/09 14:17	05/07/09 15:56	05/06/09 18:57	05/07/09 14:30
Screen Interval Depth (ft bgs)	0.7	0.45	0.4	0.6	0.05
Ambient Air Temp (°F)	68° F	68° F	68° F	~ 68° F	68° F
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
Comment No.	1	1	1	1	1

COMMENTS

1. Pre-test pressure readings collected on 5/6/09.

Subslab Monitoring Point Integrity Testing Summary

Project No.:	2999.00/020	Date: 5/6-7/09
Project Name:	IBM-EF B310 Source Investigation	
Location:	Hopewell Junction, New York	
Project Manager:	CGL	

Collector (s):	PRM, SAW
O_2 / CH_4 / CO_2 Meter Used:	GEM 2000 (Pine)
PID Meter Used:	MiniRae 2000 (Pine)
FID Meter Used:	-
He Meter:	Dielectric (Pine)
Other:	-

INTEGRITY TESTING RECORD

Location No.	**SS-11**	**SS-12**	**SS-13**	**SS-14**	**SS-15**
Performance Testing					
Vacuum (in H_20)	0.05	0.25	0.05	0.05	0.05
Time to fill 1 liter Bag	4:30	4:05	5:00	5:00	5:00
Approx. Flow Rate (L/min)	0.22	0.24	0.20	0.20	0.20
Tracer Gas Applied?	He	He	He	He	He
Tracer Gas Concentration (ppmv)	0	0	0	0	0
O_2 (%)	21.3	21.5	20.5	21.6	21.8
CH_4 (%)	0.0	0.0	0.4	0.0	0.0
CO_2 (%)	1.0	0.7	2.5	0.7	0.8
PID (ppmv)	38.2	35.5	58.5	35.9	36.8
Pre-Test Pressure (in wc)	0.000	0.000	0.000	0.005	0 to -0.003
Testing Date and Time	05/06/09 16:04	05/06/09 16:15	05/07/09 16:43	05/06/09 18:30	05/06/09 17:10
Screen Interval Depth (ft bgs)	0.45	0.40	0.45	0.5	0.52
Ambient Air Temp (°F)	~ 68° F	~ 68° F	68° F	~ 68° F	~ 68° F
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
Comment No.	1	1	1	1	1

COMMENTS

1. Pre-test pressure readings collected on 5/6/09.

Abbreviations:
NM = Not Measured

Subslab Monitoring Point Integrity Testing Summary

SHA IMPROVING EARTH	Project No.:	2999.00/020	Date:	5/6-7/09
	Project Name:	IBM-EF B310 Source Investigation		
	Location:	Hopewell Junction, New York		
	Project Manager:	CGL		

Collector (s):	PRM, SAW
O_2 / CH_4 / CO_2 Meter Used:	GEM 2000 (Pine)
PID Meter Used:	MiniRae 2000 (Pine)
FID Meter Used:	-
He Meter:	Dielectric (Pine)
Other:	-

INTEGRITY TESTING RECORD

Location No.	**SS-16**	**SS-17**	**SS-18**	**SS-19**	**SS-20**
Performance Testing					
Vacuum (in H_20)	0.70	0.05	0.05	0.05	0.05
Time to fill 1 liter Bag	5:00	5:00	5:00	5:00	5:00
Approx. Flow Rate (L/min)	0.20	0.20	0.20	0.20	0.20
Tracer Gas Applied?	He	He	He	He	He
Tracer Gas Concentration (ppmv)	0	0	0	0	0
O_2 (%)	21.3	20.3	21.3	21.2	18.5
CH_4 (%)	0.0	0.0	0.0	0.0	0.1
CO_2 (%)	0.6	1.0	1.1	1.0	2.3
PID (ppmv)	35.1	45.2	33.0	33.1	72.0
Pre-Test Pressure (in wc)	0.000	0.000	0.000	-0.005	0.000
Testing Date and Time	05/06/09 18:10	05/06/09 17:55	05/06/09 17:41	05/16/09 7:30	05/07/09 16:57
Screen Interval Depth (ft bgs)	0.7	0.4	0.5	0.61	0.45
Ambient Air Temp (°F)	~ 68° F	~ 68° F	~ 68° F	~ 68° F	68° F
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
Comment No.	1	1	1	1	1

COMMENTS

1. Pre-test pressure readings collected on 5/6/09.

Subslab Monitoring Point Integrity Testing Summary

SHA IMPROVING EARTH	Project No.:	2999.00/020	Date:	5/6-7/09
	Project Name:	IBM-EF B310 Source Investigation		
	Location:	Hopewell Junction, New York		
	Project Manager:	CGL		

Collector (s):	PRM, SAW
O_2 / CH_4 / CO_2 Meter Used:	GEM 2000 (Pine)
PID Meter Used:	MiniRae 2000 (Pine)
FID Meter Used:	-
He Meter:	Dielectric (Pine)
Other:	-

INTEGRITY TESTING RECORD

Location No.	**SS-21**	**SS-22**			
Performance Testing					
Vacuum (in H_20)	30	0.05			
Time to fill 1 liter Bag	8:30	5:30			
Approx. Flow Rate (L/min)	0.12	0.18			
Tracer Gas Applied?	He	He			
Tracer Gas Concentration (ppmv)	0	0			
O_2 (%)	21.3	19.4			
CH_4 (%)	0.0	0.1			
CO_2 (%)	0.7	2.9			
PID (ppmv)	53.0	94.6			
Pre-Test Pressure (in wc)	0.000	0.000			
Testing Date and Time	05/06/09 16:55	05/07/09 16:28			
Screen Interval Depth (ft bgs)	1.0	0.47			
Ambient Air Temp (°F)	~ 68° F	68° F			
Weather Conditions	Inside Bldg	Inside Bldg			
Comment No.	1	1			

COMMENTS

1. Pre-test pressure readings collected on 5/6/09.

Subslab/Soil Vapor Field Sampling Summary

SHA IMPROVING EARTH	Project No.:	2999.00 / 020	Date:	5/5-6/09
	Project Name:	IBM-EF, B310		
	Location:	Hopewell Junction, NY		

O_2 / CH_4 / CO_2 Meter Used: GEM 2000	Project Manager: CGL
PID Meter Used: MiniRae	Collector(s): CGL, PRM, MTS, SAW
Other:	FID Meter Used: -

SUBSLAB/SOIL VAPOR SAMPLE RECORD

Location No.	**SS-01**	**SS-02**	**SS-03**	**SS-04**	**SS-05**	**SS-06**
Sample ID	SS01	SS02	SS03	SS04	SS05	SS06
Implant Install Date	5/4/09	5/4/09	5/4/09	5/5/09	5/4/09	5/5/09
Sample Date	5/5/09	5/5/09	5/5/09	5/5/09	5/6/09	5/6/09
Sample Collection Depth/ Slab Thickness (ft bgs)	1.0	1.0	1.1	0.4	0.5	0.7
Approx. Purge Volume (cm^3)	138	138	152	55	82	113
Canister Serial No.	3457	3299	3368	3302	3356	3349
Start Time	1444	1525	1525	1526	0721	0730
Start Pressure (inches Hg)	-30.0	-29.5	<- 30	<- 30	<- 30	-30
Stop Time	1545	1631	1652	1648	0837	0844
Stop Pressure (inches Hg)	-7.0	-7.5	-9.0	-8.0	-7.0	-6.0
Ambient Air Temp (°F)	73	73	73	~ 68	~ 68	~ 68
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
O_2 Reading (%)	20.5	21.1	21.3	20.6	16.6	18.8
CH_4 Reading (%)	0.0	0.0	0.0	0.1	4.9	1.7
CO_2 Reading (%)	1.3	1.5	1.0	1.7	7.6	3.8
PID reading (ppmv)	247	584	171	44.5	43.5	248
SapphIRe reading (ppmv)	(77)	(31)	(8)	(27)	-	-
Comment No.	1					

COMMENTS

1. SapphIRe readings collected on 5/7/09 after 14:00.

Subslab/Soil Vapor Field Sampling Summary

SHA IMPROVING EARTH	Project No.: 2999.00 / 020	Date: 5/5-6/09
	Project Name: IBM-EF, B310	
	Location: Hopewell Junction, NY	

O_2 / CH_4 / CO_2 Meter Used: GEM 2000	Project Manager: CGL
PID Meter Used: MiniRae	Collector(s): CGL, PRM, MTS, SAW
Other:	FID Meter Used: -

SUBSLAB/SOIL VAPOR SAMPLE RECORD

Location No.	**SS-07**	**SS-08**	**SS-09**	**SS-10**	**SS-11**	**SS-12**
Sample ID	SS07	SS08	SS09	SS10	SS11	SS12
Implant Install Date	5/5/09	5/5/09	5/5/09	5/5/09	5/5/09	5/5/09
Sample Date	5/6/09	5/5/09	5/6/09	5/6/09	5/6/09	5/6/09
Sample Collection Depth/ Slab Thickness (ft bgs)	0.45	0.4	0.6	0.5	0.45	0.40
Approx. Purge Volume (cm^3)	74	67	97	82	8	7
Canister Serial No.	3303	3353	3361	3333	3327	3344
Start Time	0744	1526	0809	0748	0736	0740
Start Pressure (inches Hg)	-30	-29.5	<- 30	<- 30	-29	-30
Stop Time	0915	1637	0930	0850	0847	0904
Stop Pressure (inches Hg)	-6.0	-7.0	-7.5	-7.0	-7.0	-7.0
Ambient Air Temp (°F)	~ 68	~ 68	~ 68	~ 68	~ 68	~ 68
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
O_2 Reading (%)	18.4	20.4	20.0	17.2	20.9	20.7
CH_4 Reading (%)	3.6	0.1	1.4	5.7	0.0	0.5
CO_2 Reading (%)	5.6	1.8	3.3	7.3	1.7	2.3
PID reading (ppmv)	2.5	244	1.5	10.7	4.9	7.5
SapphIRe reading (ppmv)	-	(770)	-	-	-	-
Comment No.						

COMMENTS

1. Purge volumes include 5cc for external line run to summa canisters.

Subslab/Soil Vapor Field Sampling Summary

SHA IMPROVING EARTH	Project No.:	2999.00 / 020	Date:	5/5-6/09
	Project Name:	IBM-EF, B310		
	Location:	Hopewell Junction, NY		
O_2 / CH_4 / CO_2 Meter Used: GEM 2000			Project Manager: CGL	
PID Meter Used: MiniRae			Collector(s): CGL, PRM, MTS, SAW	
Other:			FID Meter Used: -	

SUBSLAB/SOIL VAPOR SAMPLE RECORD

Location No.	**SS-13**	**SS-14**	**SS-15**	**SS-16**	**SS-17**	**SS-18**
Sample ID	SS13	SS14	SS15	SS16	SS17	SS18
Implant Install Date	5/5/09	5/5/09	5/5/09	5/5/09	5/5/09	5/5/09
Sample Date	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Sample Collection Depth/ Slab Thickness (ft bgs)	0.45	0.53	0.52	0.70	0.43	0.50
Approx. Purge Volume (cm^3)	7.5	8	8	9	7.5	8
Canister Serial No.	3369	3328	3337	3323	3373	3458
Start Time	1052	1038	0807	1022	1030	0810
Start Pressure (inches Hg)	<- 30	<- 30	<- 30	<- 30	-30	<- 30
Stop Time	1215	1201	0929	1156	1157	0948
Stop Pressure (inches Hg)	-7.0	-7.0	-7.0	-7.0	-6.5	-7.0
Ambient Air Temp (°F)	~ 68	~ 68	~ 68	~ 68	~ 68	~ 68
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg
O_2 Reading (%)	21.0	21.2	20.4	20.6	20.0	20.6
CH_4 Reading (%)	0.0	0.0	0.0	0.6	0.0	0.0
CO_2 Reading (%)	1.7	1.5	1.8	2.5	1.9	2.1
PID reading (ppmv)	14.0	1.0	4.6	3.4	38.7	5.3
SapphIRe reading (ppmv)	-	-	-	-	-	-
Comment No.						

COMMENTS

1. Purge volumes include 5cc for external line run to summa canisters (~ 2 ft lengths).

Subslab/Soil Vapor Field Sampling Summary

SHA IMPROVING EARTH	Project No.: 2999.00 / 020	Date: 5/5-6/09
	Project Name: IBM-EF, B310	
	Location: Hopewell Junction, NY	

O_2 / CH_4 / CO_2 Meter Used: GEM 2000	Project Manager: CGL
PID Meter Used: MiniRae	Collector(s): CGL, PRM, MTS, SAW
Other:	FID Meter Used: -

SUBSLAB/SOIL VAPOR SAMPLE RECORD

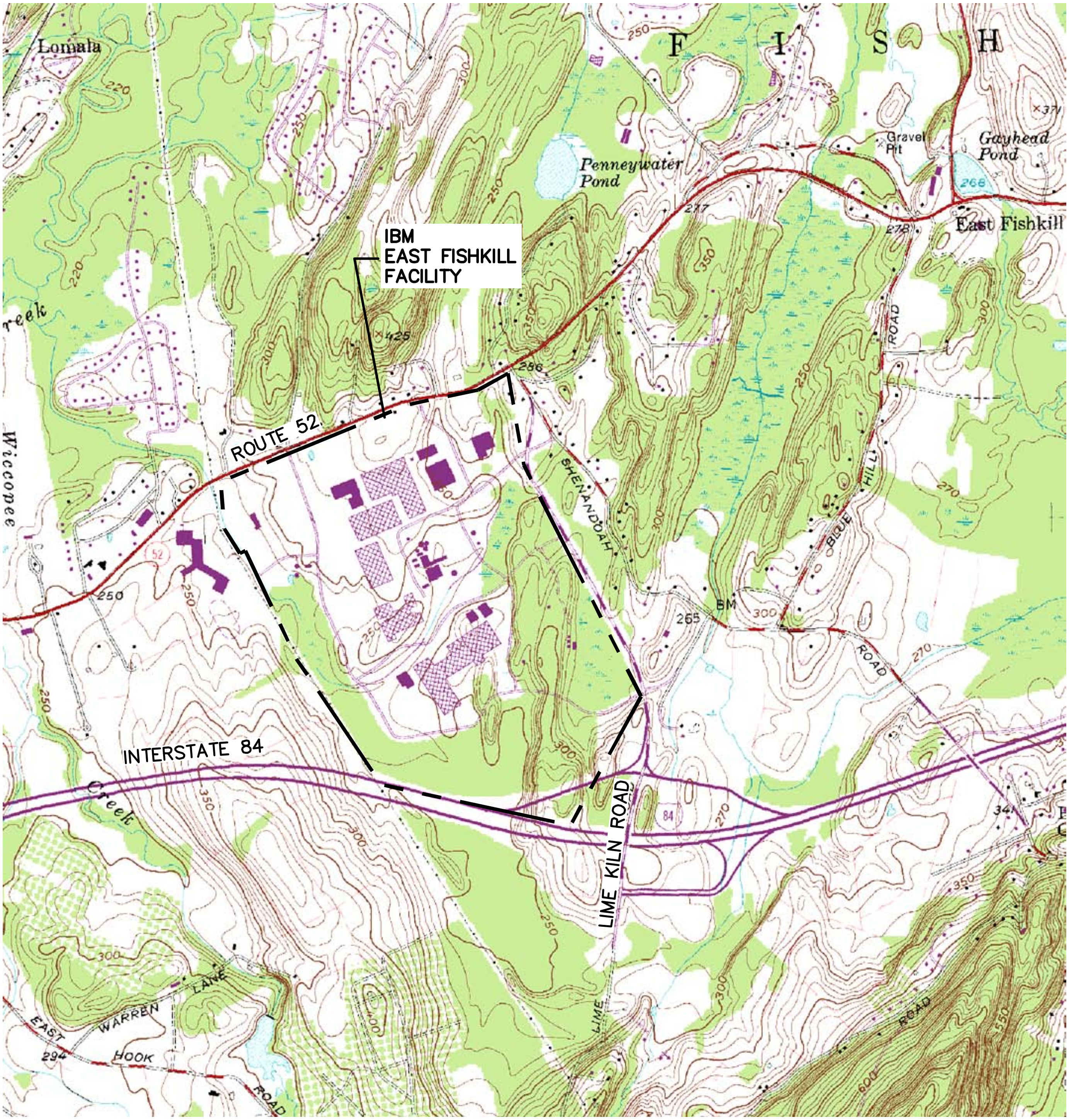
Location No.	**SS-19**	**SS-20**	**SS-21**	**SS-22**	**SS-09**	
Sample ID	SS19	SS20	SS21	SS22	Duplicate	
Implant Install Date	5/5/09	5/5/09	5/5/09	5/5/09	5/6/09	
Sample Date	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	
Sample Collection Depth/ Slab Thickness (ft bgs)	0.61	0.45	1.0	0.47	-	
Approx. Purge Volume (cm^3)	8	7.5	10.5	8	-	
Canister Serial No.	3364	3335	3322	3298	3363	
Start Time	0814	1102	0751	1045	0809	
Start Pressure (inches Hg)	-30	<- 30	-27.0	<- 30	-30	
Stop Time	0934	1221	0855	1150	0930	
Stop Pressure (inches Hg)	-7.0	-5.0	-7.0	-6.0	-7.0	
Ambient Air Temp (°F)	~ 68	~ 68	~ 68	~ 68		
Weather Conditions	Inside Bldg	Inside Bldg	Inside Bldg	Inside Bldg		
O_2 Reading (%)	20.6	18.9	16.9	19.5		
CH_4 Reading (%)	0.0	0.0	3.4	0.0		
CO_2 Reading (%)	2.0	1.8	5.3	2.4		
PID reading (ppmv)	9.6	74.0	6.7	67.4		
SapphIRe reading (ppmv)	-	-	-	-	-	
Comment No.						

COMMENTS

1. Purge volumes include 5cc for external line run to summa canisters (~ 2 ft lengths).

APPENDIX D

Copies of Laboratory Analytical Reports
(On Enclosed CD Only)



Notes:
Base map taken from 7.5 minute USGS Quadrangle Maps: Hopewell Junction, New York, Dated 1957, Photorevised in 1981.

N
W E
S

0 2000'

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

Figure 1
Locus Plan
Report of Findings -
Building 310 VOC Source Investigation
IBM East Fishkill Facility
Hopewell Junction, New York

SHPC ENGINEERS

FILE: V:\RANDOLPH\2999.00 020\dwg\Source-Invest-Report-Figs\Locus.dwg
PLOT DATE: 3-31-10

Figure 2

Building Location Plan

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

Figure Narrative

This figure shows a plan view of the buildings at the IBM East Fishkill facility. Building 310 is highlighted.

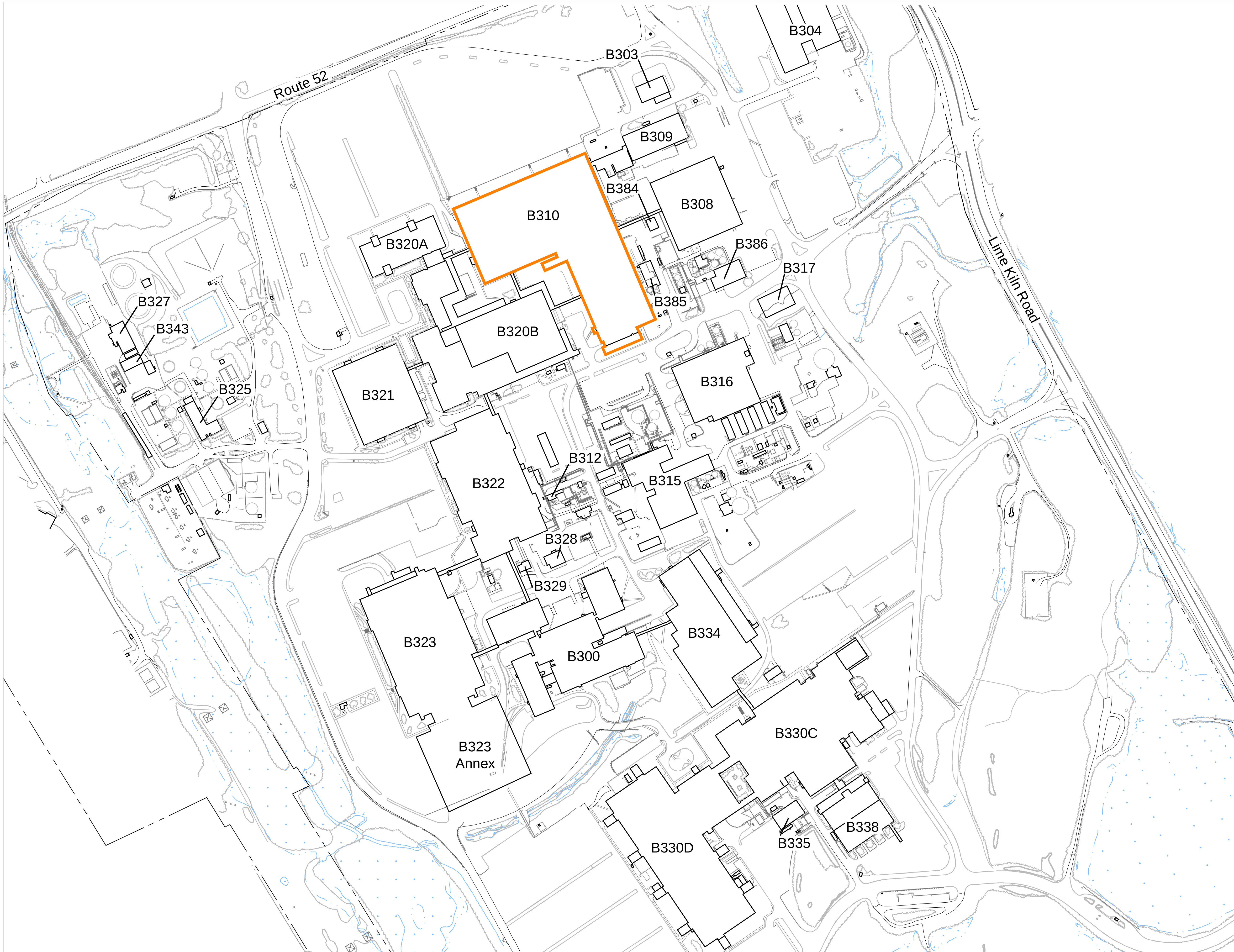
Legend

IBM Property Line

B310 Indicates building number

Indicates the location of Building 310

Unlabeled features include wastewater treatment tanks, pump houses, trailers, and other structures and features not intended for human occupancy



N
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Feet
200' 100' 0 200' 400'

SHPC
ENGINEERS

File:V:\RANDOLPH\2999.00 020\dwg\Source-Invest-Report-Figs\Building-Location-Plan.dwg Plot Date: 3-31-10

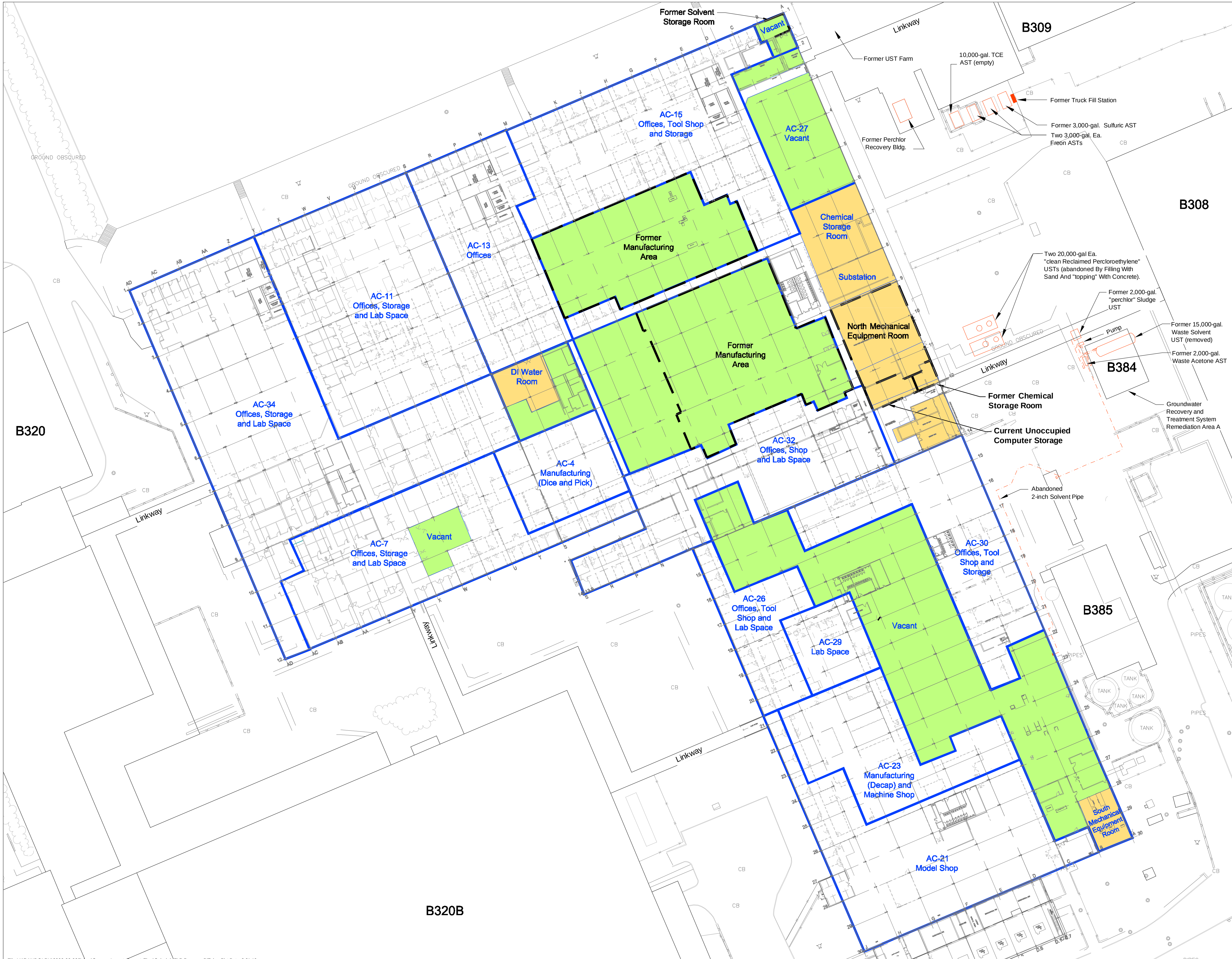

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Figure 3

Building 310 Layout and HVAC Zones

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Rev. Date: April 2010

Figure Narrative

This figure shows the layout of Building 310, current use of space, and the associated HVAC zones as indicated by a survey performed by U.S. Test and Balance of Hopewell Junction, New York in 2008 (prior to HVAC modifications in 2009) and as provided by IBM. HVAC zone boundaries have been inferred in some locations and should be considered approximate.

Legend

AC-32 — Approximate HVAC zone boundaries of specified air handling unit

Approximate boundary of identified area

Indicates area is vacant and HVAC is inactive

Indicates areas that are currently in use but are typically unoccupied

N W E S

40' 20' 0 40' 80' Feet

SHPC ENGINEERS

File:V:\RANDOLPH\2999.00 020\dwg\Source-Invest-Report-Figs\B310-Initial-screening-results.dwg Plot Date: 3-31-10

Figure 4

Initial VOC Screening Results

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

Figure Narrative

This figure shows the layout of the ground floor level of Building 310 and the results of indoor air screening performed in October and November 2008. Total volatile organic compound (VOC) screening was conducted using a hand-held photoionization detector (PID) with parts per billion by volume (ppbv) detection limit.

Legend

- Indicates a maximum VOC screening value less than 50 ppbv
- Indicates a maximum VOC screening value between 50 and 500 ppbv
- Indicates a maximum VOC screening value greater than 500 ppbv

N
W E
S

Feet
40' 20' 0 40' 80'

SHPC ENGINEERS

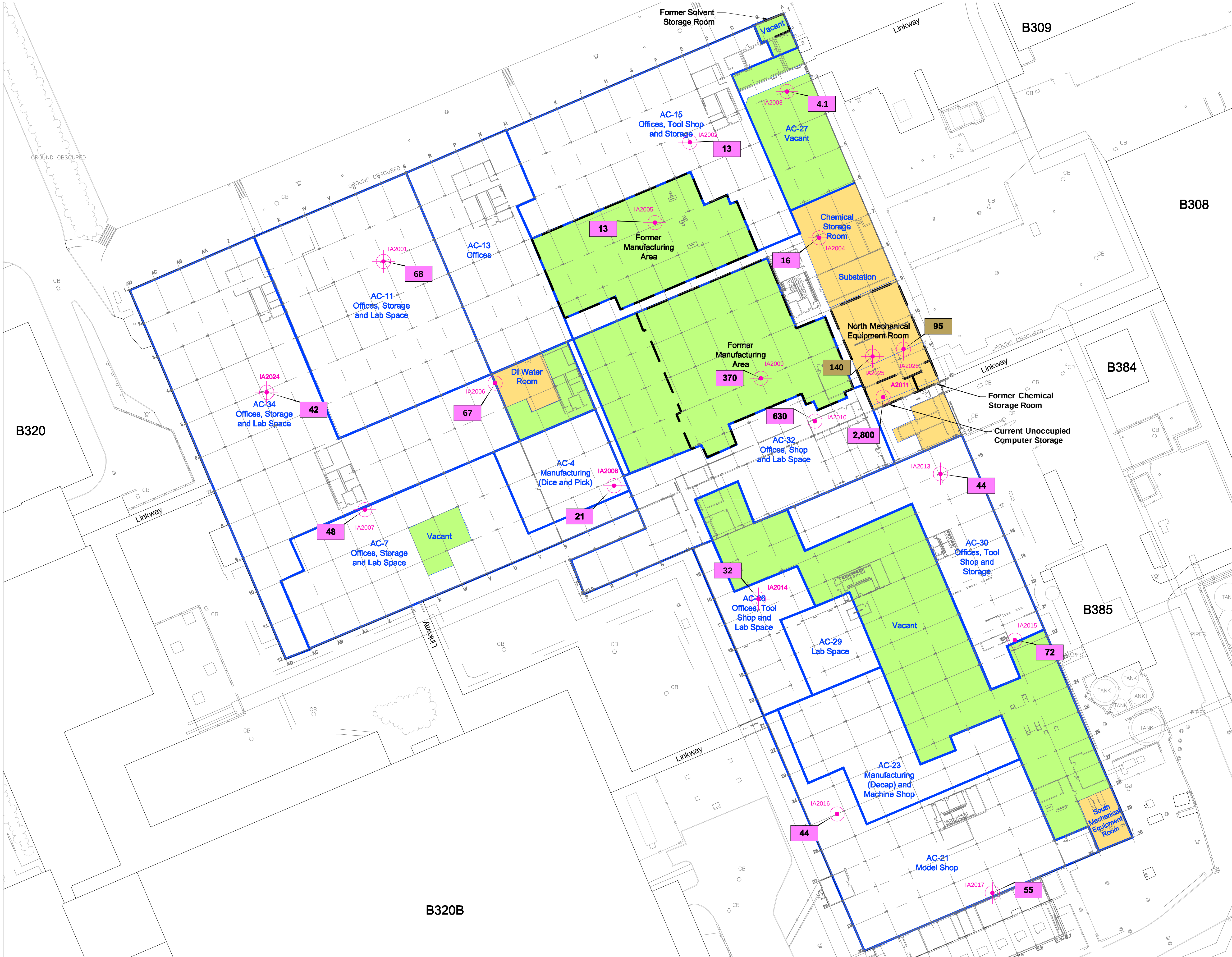


Figure 5

Summary of Initial Indoor Air Sample Results for PCE

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

Figure Narrative

This figure shows the results of interior air sampling performed in B310 by SHA personnel on the dates indicated in the legend. Results are presented in units of micrograms per cubic meter ($\mu g/m^3$).

Legend

- AC-32 — Approximate HVAC zone boundaries of specified air handling unit
- Approximate boundary of identified area
- Indicates area is vacant and HVAC is inactive
- Indicates areas that are currently in use but are typically unoccupied and where HVAC is limited to exhaust ventilation
- IA2013 — Location and designation of indoor air sample

PCE results for summa canister samples collected by IBM and SHA on the dates indicated below

- 630 — PCE results for 2/17/2009 in $\mu g/m^3$
- 95 — PCE results for 4/1/2009 in $\mu g/m^3$

N W E S

40' 20' 0 40' 80' Feet

SHPC ENGINEERS

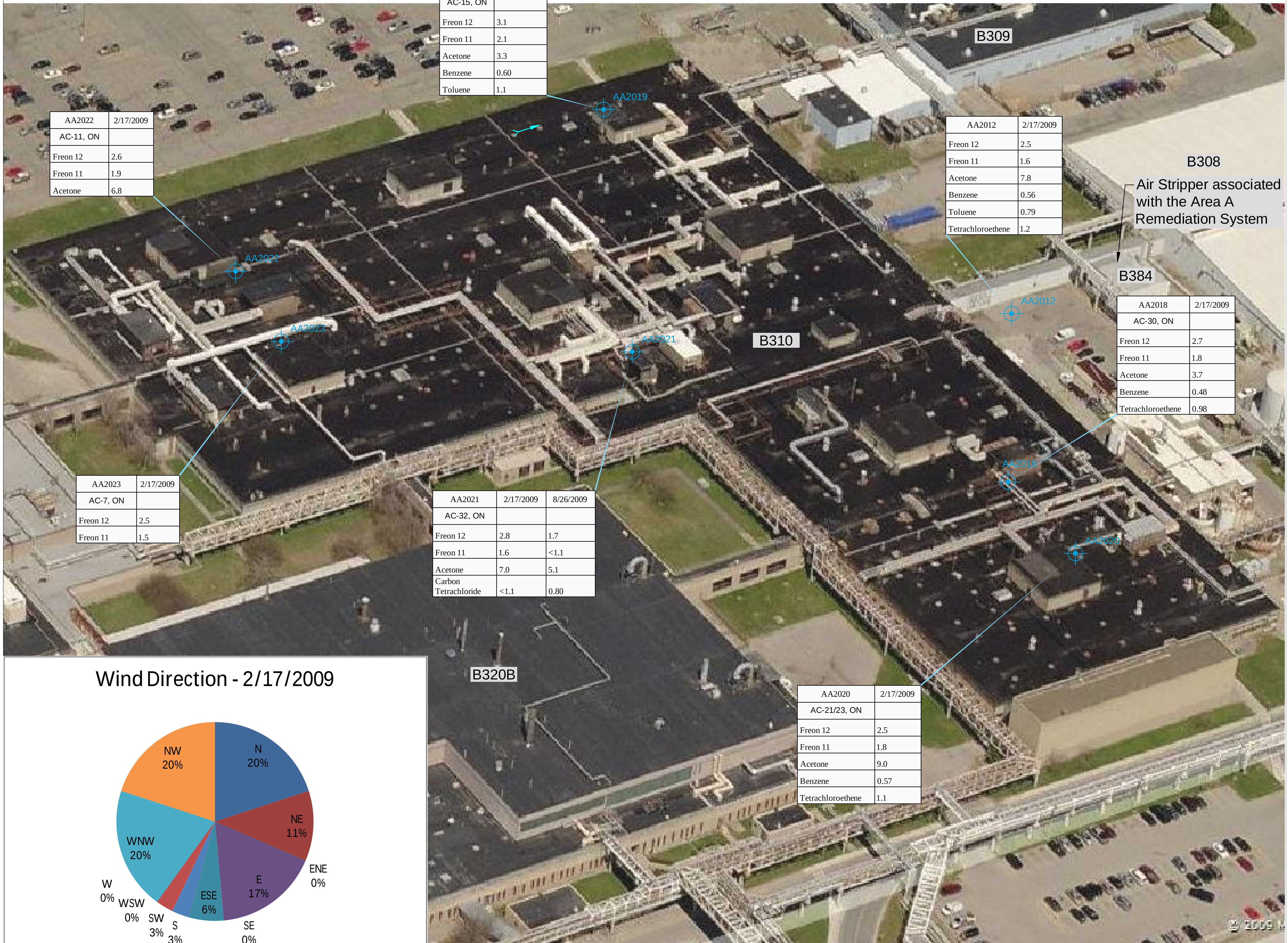
Figure 6

Ambient Outdoor Air Sample Results

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010



AA2019	2/17/2009
AC-15, ON	
Freon 12	3.1
Freon 11	2.1
Acetone	3.3
Benzene	0.60
Toluene	1.1

AA2022	2/17/2009
AC-11, ON	
Freon 12	2.6
Freon 11	1.9
Acetone	6.8

AA2012	2/17/2009
Freon 12	2.5
Freon 11	1.6
Acetone	7.8
Benzene	0.56
Toluene	0.79
Tetrachloroethene	1.2

AA2018	2/17/2009
AC-30, ON	
Freon 12	2.7
Freon 11	1.8
Acetone	3.7
Benzene	0.48
Tetrachloroethene	0.98

AA2023	2/17/2009
AC-7, ON	
Freon 12	2.5
Freon 11	1.5

AA2021	2/17/2009	8/26/2009
AC-32, ON		
Freon 12	2.8	1.7
Freon 11	1.6	<1.1
Acetone	7.0	5.1
Carbon Tetrachloride	<1.1	0.80

AA2020	2/17/2009
AC-21/23, ON	
Freon 12	2.5
Freon 11	1.8
Acetone	9.0
Benzene	0.57
Tetrachloroethene	1.1

Figure Narrative

This figure shows the results of ambient air samples collected on February 17, 2009 and August 26, 2009. Samples were collected using "Summa" canisters (summas) equipped with 8-hour flow controllers. Summas were analyzed by Air Toxics, Ltd. of Folsom, California using USEPA Method TO-15, Low Level for the IBM-EF project-specific list of volatile organic compounds (VOCs). Sample results are presented in the units of micrograms per cubic meter.

On February 17, 2009, a Davis weather station was deployed on the B310 rooftop during the indoor and ambient air sampling to collect outside temperature, wind speed, and wind direction data. The location of the weather station is shown on this figure. The wind direction data is shown on the windrose. It indicates that wind direction was predominantly from the north, northwest, and west-northwest during the sampling period. Wind direction can be used to assess potential ambient VOC sources that could affect VOC concentrations in indoor air samples.

The corresponding HVAC zone and its operational status are provided for each sample location.

Source

Aerial photo downloaded from Microsoft Virtual Earth™. Image courtesy of © 2008 NAVTEQ AND © 2008 Pictometry International Corp.

Legend

AA2020 — Location and designation of ambient (i.e., outdoor) air samples

Location of temporary weather station

AC-30, ON — Indicates HVAC zone and its operational status

N W E S

40' 20' 0 40' 80' Feet

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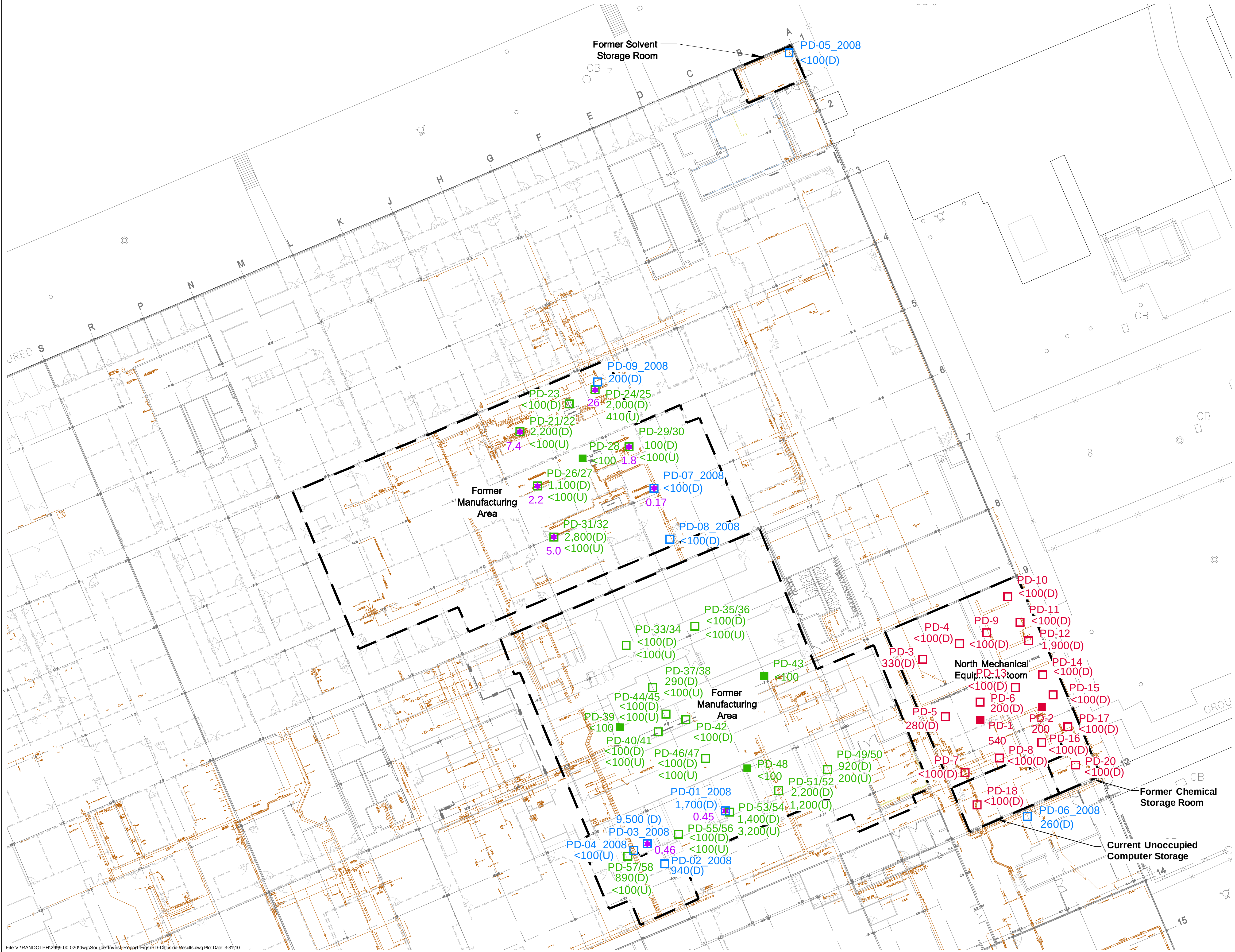

Figure 7

Targeted Floor-Level Passive Diffusion Sampler Results

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

Figure Narrative

This figure shows sampling locations and the results of targeted air sampling performed in B310 by SHA personnel on the dates noted. The November 10-11, 2008, April 1-2, 2009, and May 13-14, 2009 samples were collected by SHA using passive diffusion (PD) samplers and were analyzed by Galson Laboratories using modified NIOSH Method 1003. Results are presented in units of micrograms per cubic meter (µg/m3). In addition, select areas and building features were screened using a Miran SapphIRe infrared gas detection system capable of detecting individual volatile organic compounds (VOCs). The Miran SapphIRe was programmed to monitor for tetrachloroethene (PCE), with a detection limit of 0.09 ppmv. The screening locations and results are shown on the figure.

Legend

- PD-05_2008 — PD sampler location November 10-11, 2008
- PD-10 — PD sampler location April 1-2, 2009
- PD-1 — PD sampler location (breathing zone) April 1-2, 2009
- PD-24/25 — PD sampler location May 13-14, 2009
- PD-43 — PD sampler location (breathing zone) May 13-14, 2009
- 2,100 — PCE data shown in units of micrograms per cubic meter (µg/m^3)
- (U) — Indicates sample was facing up
- (D) — Indicates sample was facing down
- 7.4 — SapphIRe screening location with PCE data in ppmv
- Sub-grade chemical drain lines provided by IBM in AutoCAD file format

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Figure 8

Subslab Exploration Plan and Differential Pressure Monitoring Results

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Rev. Date: April 2010

Figure Narrative

This figure shows the locations of subslab vapor monitoring and extraction test ports installed in B310 on May 5-6, 2009.

Differential pressure monitoring was performed using a digital manometer capable of measuring pressures from 0.000 to 1.0 inches of water. Readings were recorded prior to integrity testing and sample collection at each location.

Legend

- SS-01 Subslab extraction test port
- SS-12 Subslab vapor monitoring port
- 0.007 Differential pressure measurement relative to room pressure in units of inches of water column (in wc). A negative value indicates subslab pressure is less than building pressure. A positive value indicates subslab pressure is greater than building pressure.
- NM Indicates not monitored

N W E S

40' 20' 0 40' 80' Feet

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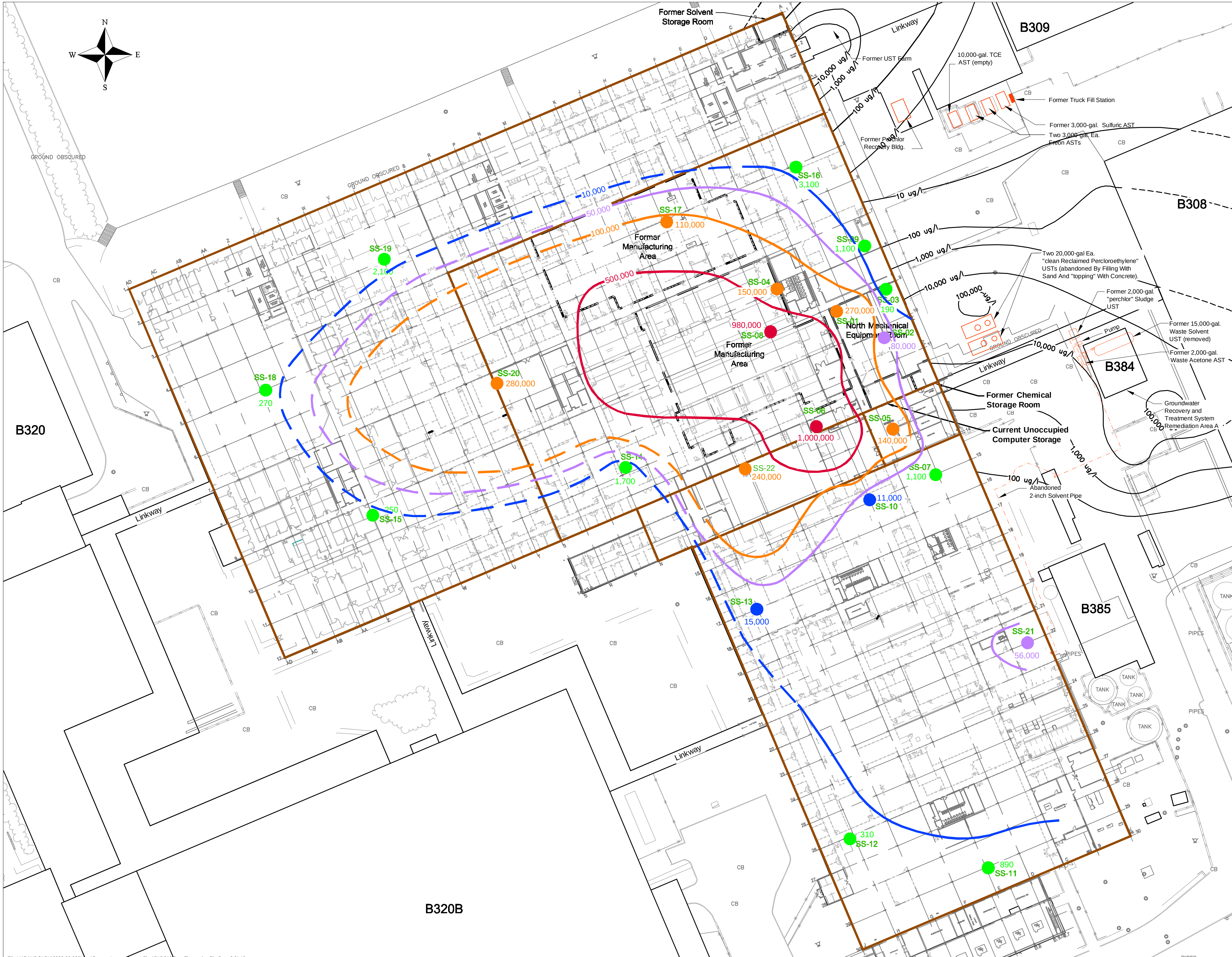

Figure 9

Subslab PCE Concentration Plan

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Rev. Date: April 2010

Figure Narrative

This figure shows the results of subslab vapor sampling performed on May 5 and 6, 2009. Subslab samples were collected into 1.0 L summa canisters equipped with 1.0 hour flow controllers. The samples were submitted to Air Toxics, Ltd. of Folsom, California for analysis of volatile organic compounds using Modified USEPA Method TO-15. The results for tetrachloroethylene (PCE) are shown in units of micrograms per cubic meter (ug/m3) with linearly inferred concentration gradients over the area sampled.

Legend

- SS-12 — Subslab vapor monitoring or extraction port identification
- 1,100 — Concentration of PCE in subslab vapor in units of microgram per cubic meter (ug/m^3)
- >500,000 to 1,000,000 ug/m^3 PCE
- >100,000 to 500,000 ug/m^3 PCE
- >50,000 to 100,000 ug/m^3 PCE
- >10,000 to 50,000 ug/m^3 PCE
- >0 to 10,000 ug/m^3 PCE
- Locations of subgrade wall (grade beam) which extends approximately 2.5' below top of floor slab
- 10 ug/l — Inferred total VOC concentrations in units of micrograms per liter in overburden groundwater perched on glaciolacustrine silt/clay

40' 20' 0 40' 80' Feet

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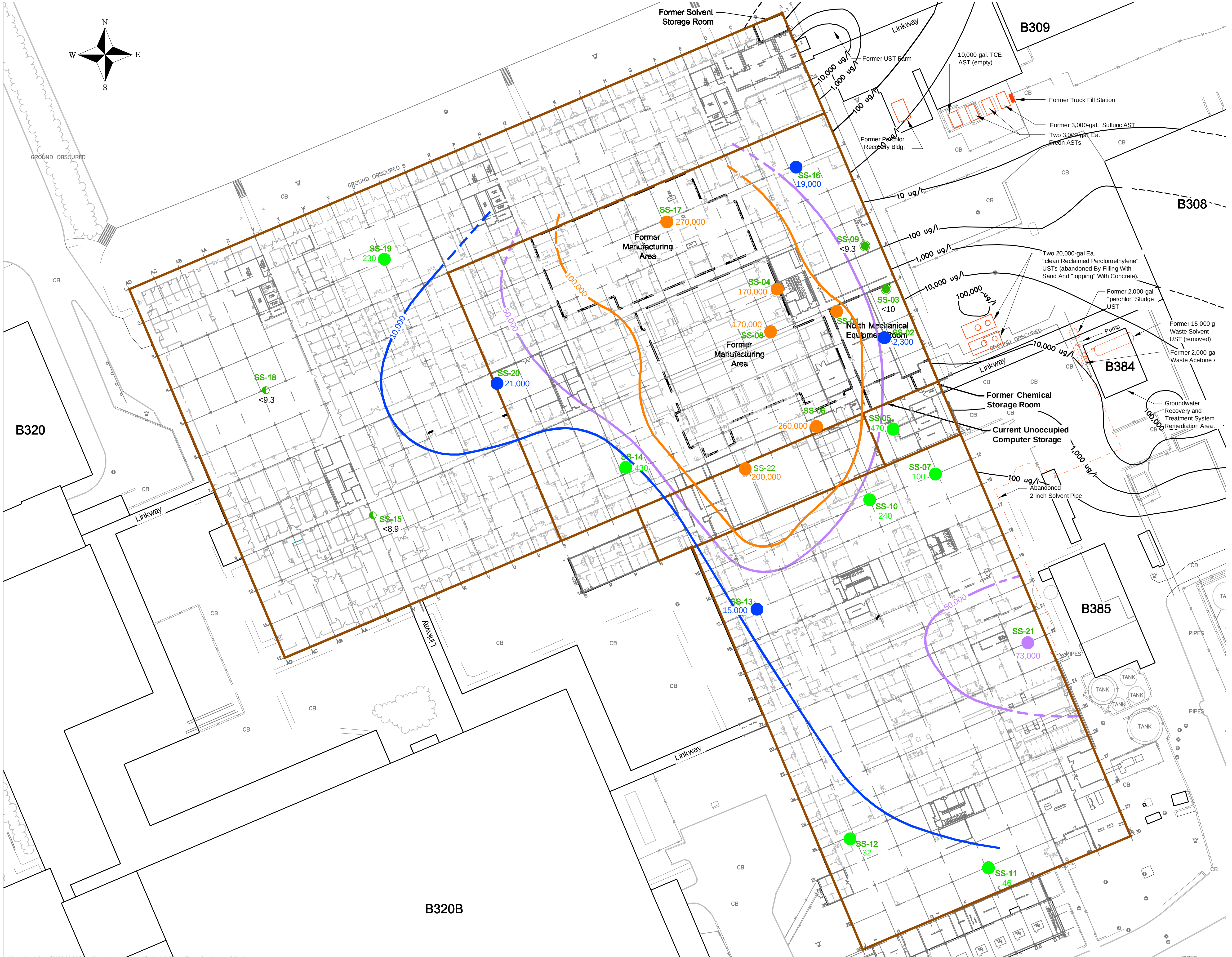

Figure 10

Subslab Freon 113 Concentration Plan

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Rev. Date: April 2010

Figure Narrative

This figure shows the results of subslab vapor sampling performed on May 5 and 6, 2009. Subslab samples were collected into 1.0 L summa canisters equipped with 1.0 hour flow controllers. The samples were submitted to Air Toxics, Ltd. of Folsom, California for analysis of volatile organic compounds using Modified USEPA Method TO-15. The results for Freon 113 are shown in units of micrograms per cubic meter (ug/m3) with linearly inferred concentration gradients over the area sampled.

Legend

- SS-12 Subslab vapor monitoring or extraction port identification
- 1,100 Concentration of Freon 113 in subslab vapor in units of microgram per cubic meter (ug/m^3)
- >100,000 to 300,000 ug/m^3 Freon 113
- >50,000 to 100,000 ug/m^3 Freon 113
- >10,000 to 50,000 ug/m^3 Freon 113
- >0 to 10,000 ug/m^3 Freon 113
- Locations of subgrade wall (grade beam) which extends approximately 2.5' below top of floor slab
- 10 ug/l Inferred total VOC concentrations in units of micrograms per liter in overburden groundwater perched on glaciolacustrine silt/clay

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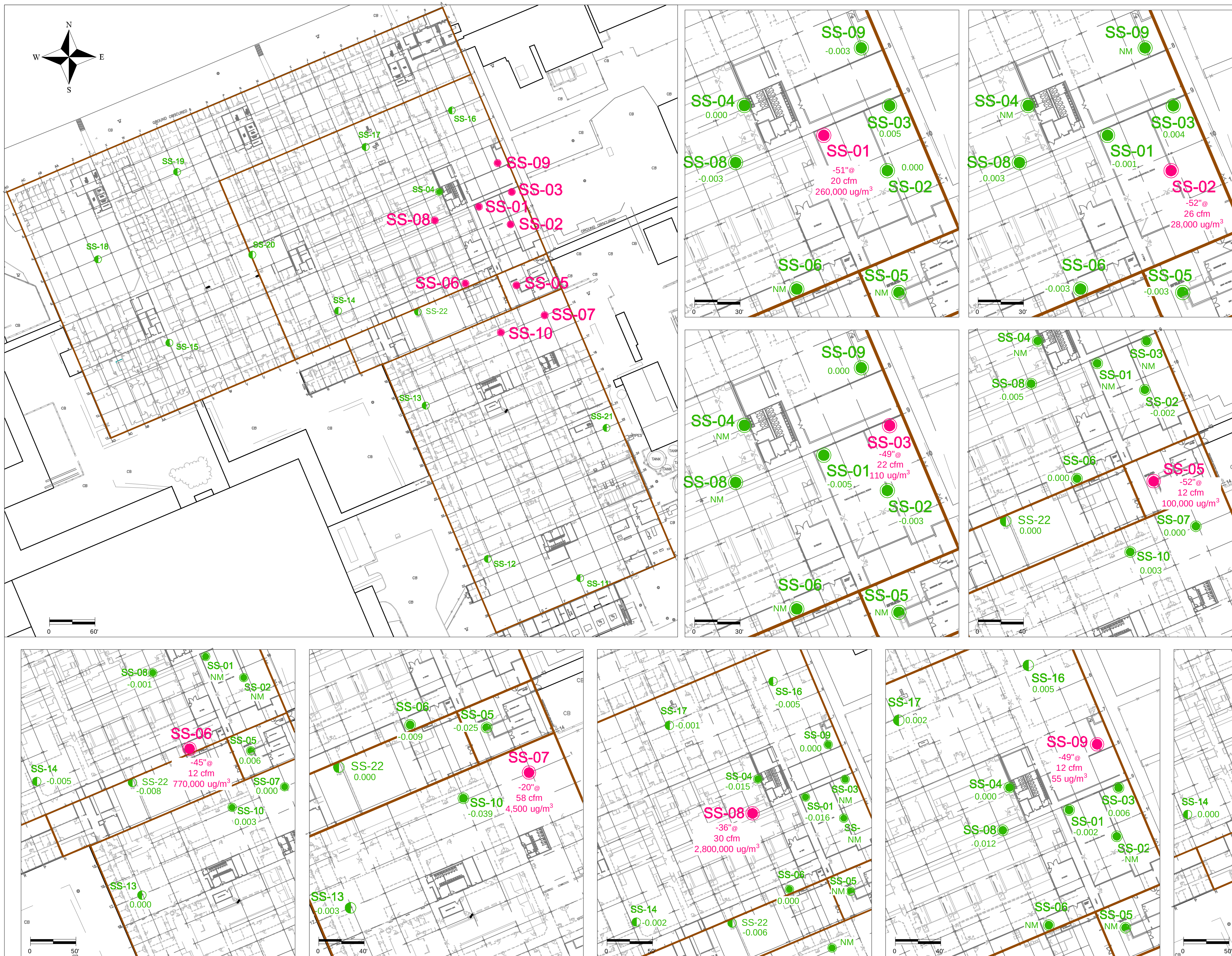

Figure 11

Subslab Pressure Response to Vapor Extraction

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Rev. Date: April 2010

Figure Narrative

Vapor extraction testing was performed on extraction ports SS-01 through SS-10 on May 6-8, 2009. Extraction testing was conducted at each extraction port at flow rates ranging from about 11 to 60 cubic feet per minute (cfm) for 30 to 65 minutes. Subslab pressure was measured at subslab monitoring ports using a digital manometer referenced to the room pressure. Subslab vapor samples were collected at the end of each extraction test. PCE concentrations for these samples are shown in micrograms per cubic meter (ug/m^3).

Each of the nine inserts show the extraction reates, vacuums, and observed changes in subslab pressure for a single test. The extraction port where the test was being performed is highlighted in red. No results are shown for the extraction test performed at SS-04 due to water in the extraction port.

Legend

- SS-01 Extraction port
- SS-12 Subslab vapor monitoring port
- Extraction port where vapor extraction testing was performed
- -52"@ 12 cfm 110 ug/m^3 — Applied pressure (i.e., vacuum) at the testing location in inches of water column ("wc), average flow rate in cubic feet per minute (cfm), and PCE concentration in ug/m^3
- 0.005 — Change in subslab pressure ("wc) at the end of vapor extraction testing
- NM — Indicates not monitored
- Approximate location of sub-grade wall

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Figure 12

Concrete and Soil Sampling Results

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Rev. Date: April 2010

SS-09	Concrete	Soil
PCE	<5	<5
TCE	<5	<5
cDCE	<5	<5
Acetone	<210	<200
Toluene	<5	<5

SS-01	Concrete	Soil
PCE	<5	30
TCE	<5	11
cDCE	<5	<5
Acetone	<200	<200
Toluene	<5	<5

SS-04	Concrete	Soil
PCE	<5	66
TCE	<5	29
cDCE	<5	<5
Acetone	430	<200
Toluene	<5	<5

SS-03	Concrete	Soil
PCE	<5	<5
TCE	<5	<5
cDCE	<5	<5
Acetone	<200	<200
Toluene	<5	<5

SS-08	Concrete	Soil
PCE	20	570
TCE	<5	24
cDCE	<5	5
Acetone	3,300	<210
Toluene	<5	<5

SS-02	Concrete	Soil
PCE	39	38
TCE	<5	<5
cDCE	<5	<5
Acetone	<200	<200
Toluene	<5	<5

SS-05	Concrete	Soil
PCE	<5	81
TCE	<5	8
cDCE	<5	<5
Acetone	<200	<200
Toluene	10	<5

SS-07	Concrete	Soil
PCE	<5	<5
TCE	<5	<5
cDCE	<5	<5
Acetone	<200	<200
Toluene	<5	<5

SS-06	Concrete	Soil
PCE	13	120
TCE	<5	7
cDCE	<5	<5
Acetone	<200	<200
Toluene	<5	<5

SS-10	Concrete	Soil
PCE	<5	950
TCE	<5	<250
cDCE	<5	<250
Acetone	<200	<2,500
Toluene	<5	<250

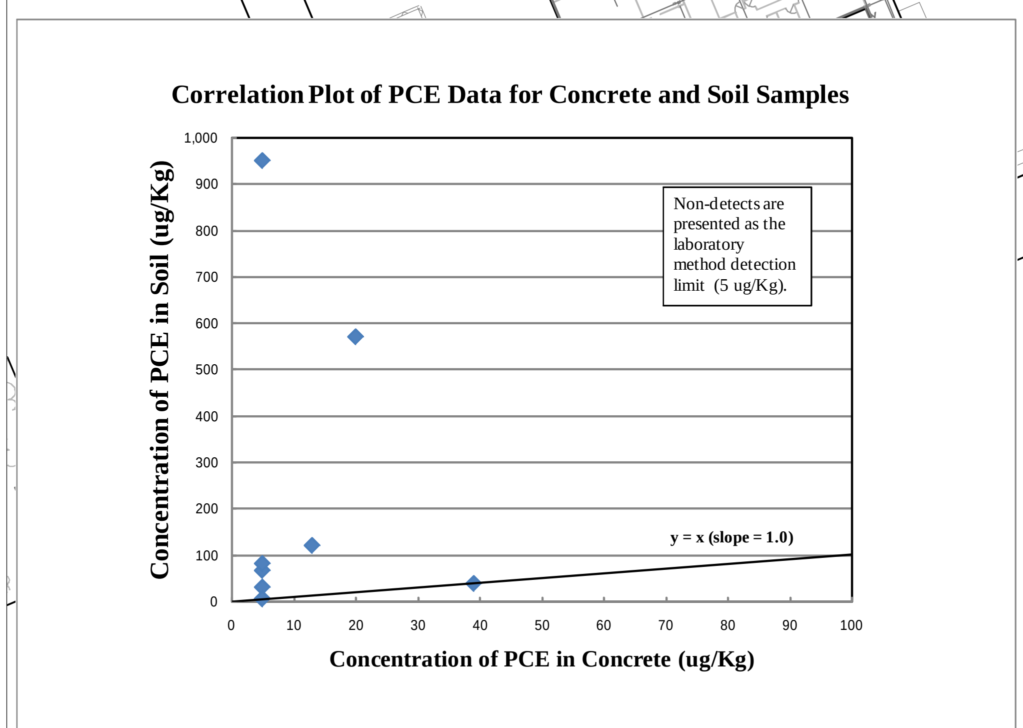

Figure Narrative

This figure shows the locations of subslab vapor monitoring and extraction test ports installed in B310 on May 5-6, 2009.

Prior to installing subslab extraction ports SS-01 through SS-10, concrete and soil samples were collected at each location. Concrete samples were collected by crushing pieces of the concrete floor slab after the location had been cored. Soil samples were collected using a Geoprobe® hand sampling kit with a 2-foot macrocore sampler. Samples were collected from approximately 2 feet below the top of slab.

Concrete and soil samples were analyzed by Groundwater Analytical for a select list of site volatile organic compounds (VOCs) using USEPA Method 8260B. This figure shows detected analytes at each sampling location. "<" indicates that the analyte was not detected above the laboratory detection limit. All results are reported in micrograms per kilogram (µg/Kg).

Legend

SS-01 Subslab extraction test port

SS-12 Subslab vapor monitoring port

N W E S

40' 20' 0 40' 80' Feet

SHPC ENGINEERS

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Figure 13

Comparison of Pre- and Post-Modification Indoor Air Sample Results for PCE

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

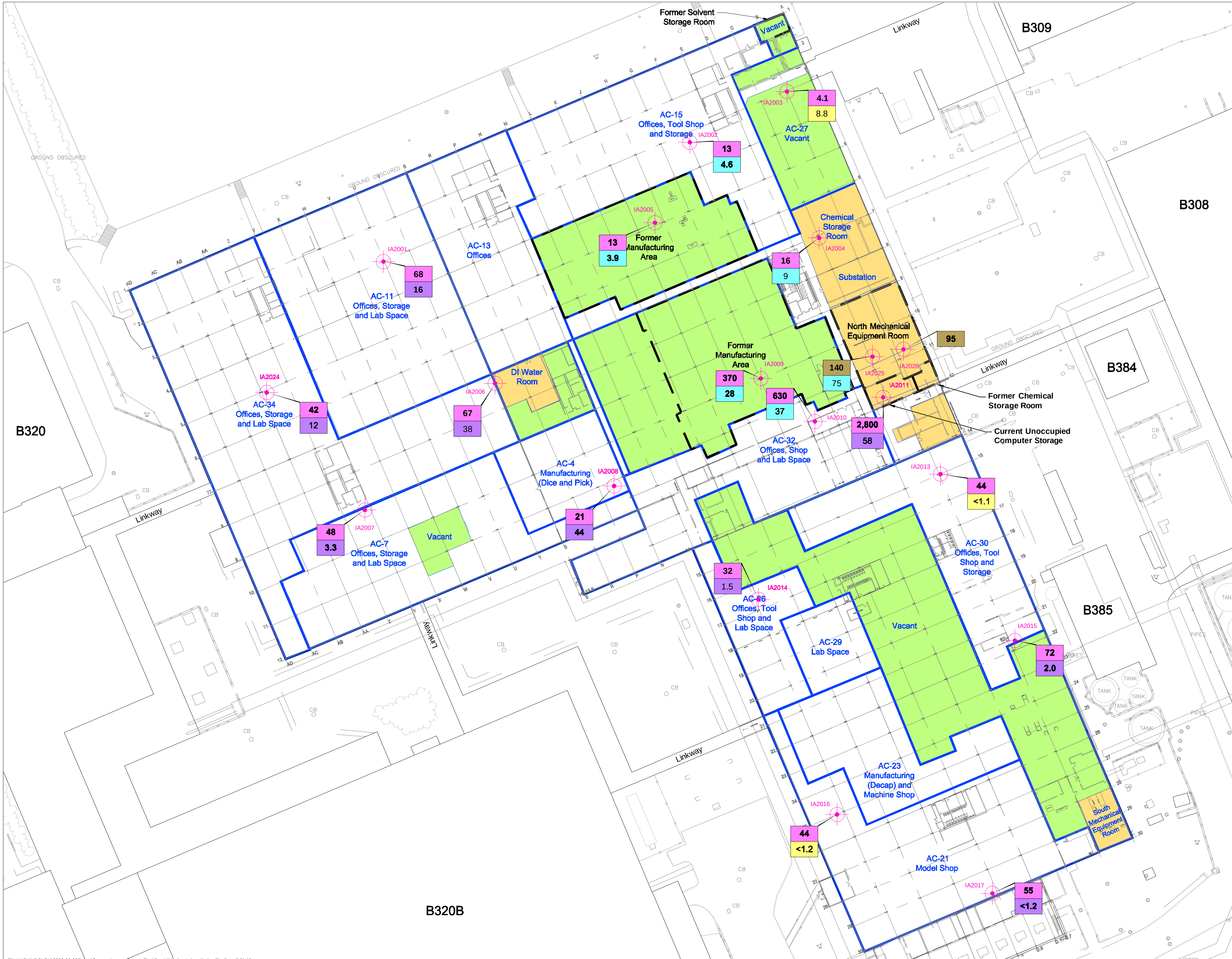

Figure Narrative

This figure shows a comparison of PCE concentrations detected in indoor air samples before and after HVAC modifications. Refer to the report text for further details.

Legend

- AC-32 — Approximate HVAC zone boundaries of specified air handling unit
- Approximate boundary of identified area
- Indicates area is vacant and HVAC is inactive
- Indicates areas that are currently in use but are typically unoccupied
- IA2013 — Location and designation of indoor air sample

PCE results for summa canister samples collected by IBM and SHA on the dates indicated below (box color represents date)

- 630 — PCE results for 2/17/2009 in µg/m^3 initial pre-modification
- 95 — PCE results for 4/1/2009 in µg/m^3 initial pre-modification
- 8.8 — PCE results for 8/26/2009 in µg/m^3 post HVAC modification
- 2.0 — PCE results for 11/20/2009 in µg/m^3 post HVAC modification
- 28 — PCE results for 12/17/2009 in µg/m^3 post HVAC modification

N S E W

40' 20' 0 40' 80' Feet

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File:V:\RANDOLPH\2999.00 020\dwg\Source-Invest-Report-Figs\Pre-Mitigation-Indoor-Air.dwg Plot Date: 3-31-10

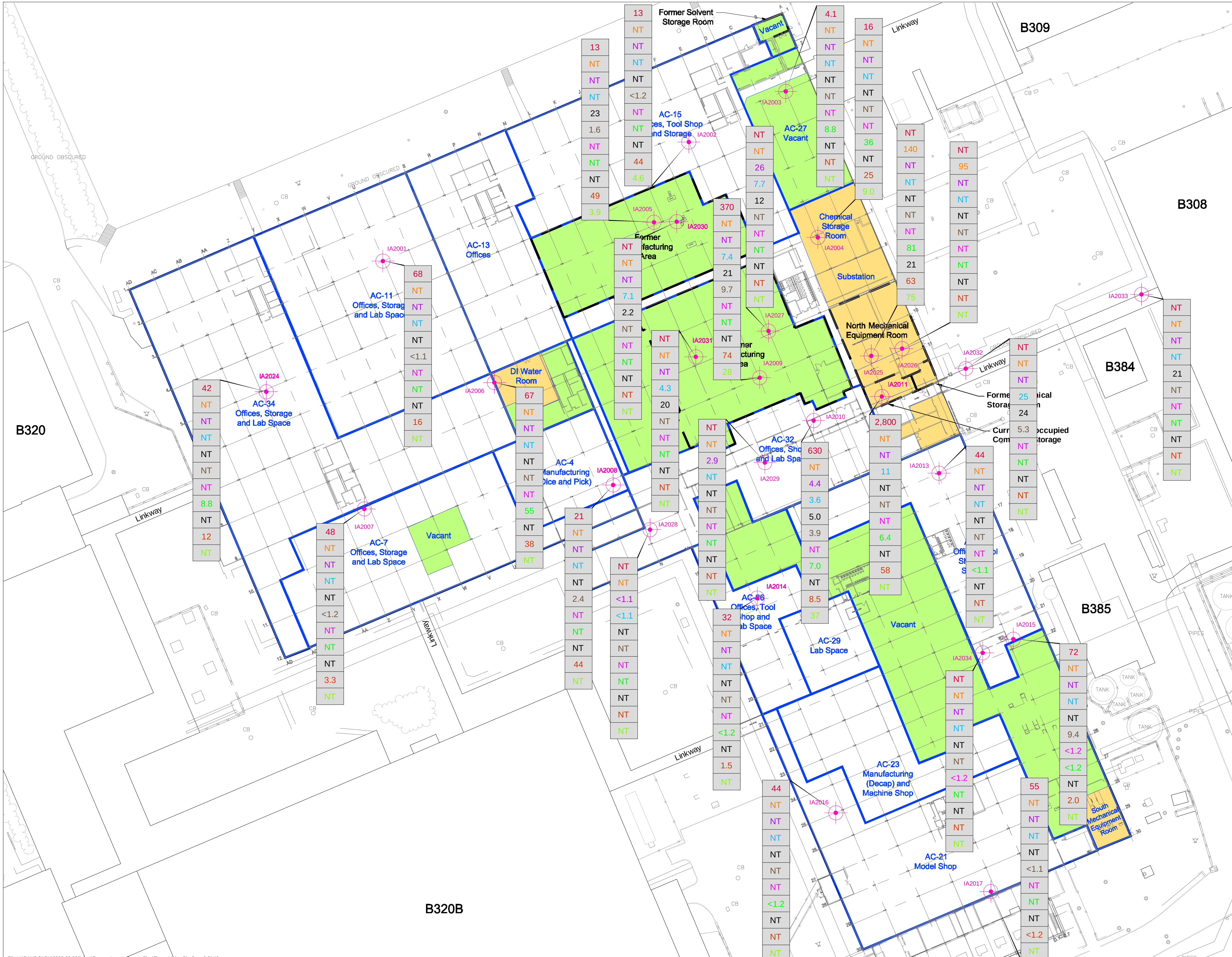

Figure 14

Summary of B310 Interior Sample Results for PCE

Report of Findings - Building 310 VOC Source Investigation

IBM East Fishkill Facility
Hopewell Junction, New York

Drawn By: E. Wright
Designed By: C. Lund
Reviewed By: D. Shea
Date: April 2010

Figure Narrative

This figure shows the results of interior air sampling performed in B310. Results are presented in units of micrograms per cubic meter (µg/m^3).

Legend

AC-32 Approximate HVAC zone boundaries of specified air handling unit

Approximate boundary of identified area

Indicates area is vacant and HVAC is inactive

Indicates areas that are currently in use but are typically unoccupied

IA2013 Location and designation of indoor air sample

PCE results for summa canister samples collected by IBM and SHA on the dates indicated below (color represents date)

630	PCE results for 2/17/2009 in µg/m^3
NT	PCE results for 4/1/2009 in µg/m^3
4.4	PCE results for 4/27/2009 in µg/m^3
3.6	PCE results for 5/13/2009 in µg/m^3
24	PCE results for 6/8/2009 in µg/m^3
5.3	PCE results for 7/8/2009 in µg/m^3
<1.2	PCE results for 7/30/2009 in µg/m^3
<1.2	PCE results for 8/26/2009 in µg/m^3
21	PCE results for 9/29/2009 in µg/m^3
12	PCE results for 11/20/2009 in µg/m^3
4.6	PCE results for 12/17/2009 in µg/m^3
NT	Indicates not tested during that sample round

N W E S

40' 20' 0 40' 80' Feet

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