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# VAPOR MITIGATION SYSTEM COMPLETION REPORT

Former TransTechnology Corporation Facility, Glen Head, New York

09/26/13

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# VAPOR MITIGATION SYSTEM COMPLETION REPORT

Former TransTechnology Corporation Facility, Glen Head, New York

09/26/13

## Client

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Whippany, New Jersey

## Consultant

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Figure 1 – Study Area

Figure 2 – As-Built Vapor Mitigation System – Home #21

Figure 2 – As-Built Vapor Mitigation System – Home #22

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# Certification

I, Kevin D. Sullivan, certify that I am currently a New York State-registered professional engineer and that this Vapor Mitigation System Completion Report was prepared in accordance with all applicable statutes and regulations and in substantial conformance with New York State Department of Environmental Conservation's *Technical Guidance for Site Investigation and Remediation (DER-10)*, dated May 2010, and that all activities were performed in full accordance with the DER-approved work plan.



Seal and Signature

09/26/2013

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# 1 Introduction

WSP, on behalf of Breeze-Eastern Corporation, prepared this report documenting the installation of vapor mitigation systems in two private residences west of the former TransTechnology Corporation facility in Glen Head, New York. The systems were installed to address chlorinated volatile organic compounds (VOCs) that were originally detected in nearby soil gas samples collected during the Operable Unit No. 2 (OU-2) investigations and later detected beneath the concrete basement slabs of homes that adjoin the facility. Breeze-Eastern offered, as a precautionary measure, mitigation systems for those with homes where the concentrations were sufficiently elevated to suggest a potential risk to the future indoor air quality (via intrusion through the basement floor) and continued monitoring for those homes where the concentrations did not warrant action.

Although originally part of the offsite soil gas and groundwater investigations, the design and installation work associated with the vapor mitigation systems were performed under a parallel investigation and remediation track separate from OU-2 with the guidance and the approval of the New York State Departments of Environmental Conservation (NYSDEC) and Health (NYSDOH). This approach was adopted to provide more flexibility in working with the individual property owners and to permit more timely action to protect the health of the residents, if necessary, than would otherwise be allowed under the normal regulatory framework. The process was further streamlined by using the prescriptive investigation techniques, data evaluation, and remedial approach (i.e., using the presumptive remedy of sub-slab depressurization [SSD]) described in the *Guidance for Evaluating Soil Vapor Intrusion in the State of New York*, dated October 2006. A detailed description of the remedial action for the two homes is provided below.

All of the work was conducted in accordance with the ASTM *Standard Practice for Installing Radon Mitigation Systems in Existing Low-rise Residential Buildings* (ASTM E-2121), dated February 10, 2003, and the procedures outlined in the approved *Work Plan for the Installation of Vapor Mitigation Systems*, dated June 7, 2012. Approval to enter the individual homes was obtained through a written access agreement included as part of the investigation reporting process. The installation activities were performed by Envirosafe Inspections & Consulting, of Honeoye, New York, a radon mitigation contractor certified by the National Environmental Health Association's (NEHA's) National Radon Proficiency Program (NRPP). The installations were supervised by a WSP engineer working under the direction of a New York State-licensed professional engineer (PE). All electrical work conducted at the homes was performed by a New York State-licensed electrician. No construction or other permits were required<sup>1</sup> for the work performed.

## 1.1 Report Organization

This report describes the general procedures used for assessing the individual homes and designing site-specific vapor mitigation systems and is presented in four sections, including this introduction:

- Section 2 provides a brief description of the background (for context), including the soil gas sampling performed during the OU-2 investigations.
- Section 3 presents the scope of work, which includes an overview of the system design approach, the general procedures used, and a narrative describing the specific testing and construction methods used for each home.
- Section 4 presents a summary of the activities and discusses the ongoing monitoring and reporting for the vapor mitigation systems.

As requested by the Departments, the addresses for the two homes have been omitted from this report to protect the privacy of the individual homeowners. Instead, WSP uses the generic home ID numbers (home # 21 and home #22) that were assigned to the properties as part of the *Offsite Indoor Air Evaluation Work Plan*, dated March 1,

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<sup>1</sup> Building permit applications were completed for both homes based on guidance received from the Town of Oyster Bay, the municipal authority in Glen Head, at the beginning of the project. The permit applications were submitted in January 2013, but were returned to WSP without approval on February 24, 2013. Subsequent negotiations over the permitting process led the town to review their initial ruling on the need for the permit and to issue an exemption on April 29, 2013.

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2012. Likewise, descriptions of the soil gas sampling in the background section of this report have been generalized to minimize the potential that the individual homes can be identified based on the sample locations (the OU-2 investigation area and the homes that received the mitigation system are included within the *Study Area* box shown on Figure 1). A detailed presentation of the OU-2 soil gas sampling is presented in the *Supplemental Remedial Investigation Report for Operable Unit No. 2*, dated January 11, 2013.

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## 2 Background

In 2011, WSP performed a series of offsite investigations to determine if affected groundwater and soil gas previously detected at onsite sample locations had migrated beyond the facility's western (downgradient) property line. The work, part of the OU-2 investigations, included installing several co-located groundwater profile and soil gas sample points in the street and right-of-way of the Todd Estates neighborhood directly west of the facility (Figure 1). The majority of the sample locations were positioned along Todd Drive East which runs parallel with the length of the TTC facility property, with the balance of the points installed in Todd Estates further to the northwest along the suspected groundwater flow path. WSP installed four additional soil gas sample points on the TTC site in a transect parallel to the western property line during a later phase of work. All of the soil gas samples were collected from approximately 6 feet below ground surface using the procedures outlined in the *Residential Reclassification and Feasibility Study Work Plan*, dated December 9, 2011.

The results of the offsite soil gas sampling revealed concentrations of VOCs tetrachloroethene (PCE), associated primarily with regional groundwater plume underlying the site and most of the adjoining neighborhoods<sup>2</sup>; and trichloroethene (TCE), which is both a PCE degradation daughter product and the primary constituent of concern at the former TTC facility. Relatively low concentrations of both compounds were detected over a wide area beneath Todd Estates with most exhibiting similar concentrations of PCE and TCE. Only one offsite sample contained a concentration of TCE that was substantially higher than the PCE concentration and was well above (one order of magnitude) the concentrations noted in the surrounding points. Similar results were obtained for the onsite soil gas samples where one location contained TCE at a concentration that was significantly higher (two to three orders of magnitude) than those in the surrounding points.

### 2.1 Vapor Intrusion Investigations

WSP performed follow-up vapor investigations in 2012 based on the OU-2 soil gas results, including the evaluation of six<sup>3</sup> homes in the study area that were identified as having the highest potential risk for vapor intrusion (Figure 1). The homes selected were directly adjacent to the former TTC facility in an area that overlies the plume of TCE-affected groundwater and in close proximity to the soil gas samples with the highest TCE concentrations. The evaluation included collecting concurrent sub-slab soil gas samples and indoor air samples from the basement and first floor of each home, and an ambient (outdoor) air sample using the techniques outlined in the *Offsite Indoor Air Evaluation Work Plan*, dated March 6, 2012.

The results revealed four homes with chlorinated VOC concentrations in the sub-slab soil gas that, according to the NYSDOH's guidance, warranted mitigation (the results from the two remaining homes yielded recommendations for further monitoring only). WSP provided the sampling results to the NYSDEC, NYSDOH, and the homeowners in individualized reports with a layperson's explanation of the data's meaning and interpretation. Breeze-Eastern also included an offer to install mitigation systems as a precaution against the potential for future vapor intrusion into the indoor air. Two of the four homeowners where action was warranted elected to accept the offer and have a vapor mitigation system installed in their homes.

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<sup>2</sup> As detailed in the *Supplemental Remedial Investigation Report for Operable Unit No. 2*, dated January 11, 2013.

<sup>3</sup> Seven homes were originally identified for the evaluation (as detailed in the *Offsite Indoor Air Evaluation Work Plan*); however, one homeowner declined to participate in the evaluation.

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## 3 Scope of Work

The vapor mitigation systems offered to the homeowners operate as an active SSD system, which, according to the NYSDOH, when combined with careful sealing of basement infiltration points (e.g., cracks, drains, wire and pipe penetrations, etc.), is an effective method for preventing the infiltration of vapors into a building's interior. The SSD system works by extracting and venting the sub-slab soil gas through the use of sealed suction points piped to a fan or blower, which creates a negative pressure below the basement floor. The pressure differential between the indoor air and the sub-slab zone reverses the normal pressure gradient (i.e., indoor air flows out instead of the soil gas flowing into the building); thereby, preventing vapors from passing from the subsurface into the building.

The systems selected for the homes were designed with in-line fans similar to those used for radon mitigation. These systems have a well-established record for long-lasting, maintenance-free operation and effective mitigation of sub-slab vapors. The fans were installed within the exhaust riser mounted in the garage of each home to facilitate future maintenance and inspections (workers will only need to enter the garage to inspect and/or change the fan motor) and to minimize any potential noise impacts from the fan during operation. The design included two or three sub-slab extraction points, depending on the basement configuration, the condition of the concrete floor, and the level of measured vacuum response. Each extraction point was fitted with a gate valve to control air flow and velocity and a U-Tube manometer to measure differential pressure and allow the inspector or homeowner to visually confirm that the system is working properly. The extraction points were manifolded into a common exhaust riser, which included a weatherproof vent cap above the roofline to minimize weather-related problems. The system installation procedures for the two homes are provided below.

### 3.1 General Installation Procedures

The vapor mitigation system installation activities were performed in several phases, including:

- Pre-installation inspection and testing
- System construction and basement modification
- System startup

The pre-installation inspection and testing activities for both homes were conducted in October 2012 shortly after obtaining signed access agreements from both homeowners. The activities included a visit to the homes to assess the overall condition and configuration of the basements and evaluate the level of sub-slab vapor communication. The inspection was focused on determining if crawl spaces were present (and if so, how were they floored) and locating any floor penetrations, such as piping runs, drains, sumps, or pipe cleanouts that might require sealing to avoid a potential short-circuit of the sub-slab vacuum with the indoor air. An elastomeric sealant was used to fill small diameter openings, thin cracks, and spaces around pipes. A sheet of Plexiglas (glued to the floor with the sealant) was used to seal sumps found in each home (see detailed description for each home below).

The communication testing was performed to aid in locating the vapor extraction point(s) such that the applied vacuum field would extend beneath the entire basement floor. The testing included drilling a series of 3/8-inch diameter holes through the concrete slab, one of which was used to apply a temporary vacuum to the subsurface (using a wet/dry vacuum) with the remaining points used to measure the response at varying distances from the temporary extraction point. If insufficient vacuum (i.e., less than 0.004 inch of water column [WC]) was measured at a monitoring location, additional holes were drilled closer to the extraction point until the vacuum field beneath the floor had been mapped. At the conclusion of the test, all penetrations were sealed with elastomeric joint sealant. The results of the communication testing, provided on the schematic drawings for each home, were used to determine the appropriate number and location for the SSD vacuum extraction points and to select the appropriate fan size.

The system construction began in June 2013 and included concrete coring to create the extraction points, installing extraction point risers and manifold piping, and installing the mitigation fan and exhaust riser to discharge extracted

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vapors outside of the home. Both home owners elected to have the piping routed through adjoining garages and vented to the atmosphere through a roof penetration rather than the typical construction where the vent stack is secured to the outside of the home. WSP also agreed to provide both homeowners (at their request) with an epoxy seal coating<sup>4</sup> for the basements once the system installation was complete. The specific construction procedures used for each home are described below.

Post-installation communication testing was conducted after the installation activities were completed to ensure that sufficient vacuum was being induced beneath the entire slab. The test was conducted by re-opening the holes drilled through the slab for the pre-installation testing, and measuring the vacuum using a digital manometer. Data collected during the post-installation testing are presented on Figures 2 and 3. The holes were resealed with elastomeric joint sealant after completing the test. As part of the post-installation process, WSP's field personnel instructed the homeowners on how to read the system manometers and periodically check the system for proper operation. The homeowners were also instructed to notify either WSP or Breeze-Eastern if they notice a problem with their SSD system (e.g., abnormal fan noise, manometer shows no vacuum), or if a component of the SSD system becomes damaged. Contact information for both companies was affixed directly to the system piping.

## 3.2 Installation at Home #21

The initial site visit for home #21 was performed on September 13, 2012. An inspection of the home revealed a full-height (approximately 8 feet-high) L-shaped basement beneath the original footprint of the home (Figure 2). The foundation walls appeared to be poured concrete and were matched with a contiguous concrete pad that covered the entire basement. Several small openings were noted in the floor, including a dry sump in the northwest corner of the basement, and around drainage pipes along the north wall. The basement was partially framed with a utility room, containing the furnace, hot water tank, and the home's main electrical breaker box located in the northeast corner. The basement also included a relatively small, elevated crawl space attached to the southeast corner of the basement underlying an addition to the home. The crawl space was approximately 3.5 feet in height and included a poured foundation wall and a contiguous poured concrete floor. Access to the crawl space was through an opening in the main foundation wall near the southeast corner of the basement.

Communication testing was performed initially using five vacuum monitoring locations, designated VM-1 through VM-5, positioned within the main basement with VM-5 used as the vacuum extraction point for the test (Figure 2). The vacuum was applied using a portable wet/dry vacuum capable of generating a vacuum of approximately 60 inches of WC. The vacuum was introduced to the subsurface by holding the hose over the opening in the concrete. Vacuum measurements, collected at each of the VM locations using a digital manometer, ranged between -0.014 and -0.406 inch of WC at VM-4 and VM-1, respectively, indicating that vacuum influence was present beneath the entire basement floor. No communication testing was performed within the crawl space due to access issues during the initial site visit. WSP assumed that construction beneath the crawl space would have a similar response to that of the main basement and deferred communication testing in this area to post construction testing.

### 3.2.1 System Design and Testing

The vapor mitigation system designed for home #21 initially included just two vacuum extraction points based on the communication testing results: EP-1, located in the main basement, and EP-2, located within the crawl space (Figure 2). Extraction point EP-2 was included to ensure vacuum coverage under the crawl space, the floor of which is at a different elevation than the main basement. A third extraction point, EP-3, was added in the northwest corner of the basement after the post-installation vacuum measurements at VM-02 showed relatively weak response (-0.009 inch of WC), only slightly above the minimum vacuum response criteria of -0.004 inch of WC. All three extraction points were created by coring a 5-inch diameter hole through the basement floor using a concrete

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<sup>4</sup> The epoxy seal coatings were provided by Breeze-Eastern to the homeowners to facilitate access to the properties for the VMS installations. The epoxy coatings do not serve a technical role in the mitigations construction.

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coring machine. The material directly below the opening in the slab was excavated to form a cavity beneath the slab, which was subsequently filled with gravel to aid in propagating the vacuum beneath the floor. A vertical extraction riser, consisting of 4-inch inside-diameter (ID) Schedule 40 PVC, was then inserted into the cored hole and sealed to the floor using a non-shrinking grout. The riser was fitted with a PVC gate valve (to control the flow) and manometer, and then plumbed to additional 4-inch ID PVC vapor extraction piping (suspended from the basement ceiling), which was manifolded with the EP-2 and EP-3 risers and routed through the southern wall of the basement. The extraction piping was then directed to the ceiling of the garage where it was connected to a Fantech HP Series Model 220 in-line fan with the exhaust vented through a vertical stack penetrating the roof. Electrical power for the fan was supplied by a dedicated electrical breaker located in the breaker panel in the northeast corner of the basement. Switches for the fan were mounted in the garage ceiling to prevent accidental shut-down of the system.

Post-installation testing of the system (with all three extraction points) was conducted on June 18, 2013, by opening the gate valves on each extraction point riser, turning on the fan, and running the system continuously for approximately 15 minutes (to allow the vacuum field to propagate outward from each extraction point beneath the concrete slab). Vacuum measurements collected from the VM points installed during the pre-installation activities and three new VM points, installed in the crawl space (VM-6 and VM-7) and along the north wall of the basement (VM-8), showed good response with vacuums ranging between -0.097 and -0.460 inch of WC (Figure 2). Differential pressure readings at the exhaust stack indicated that the system was generating a vacuum of approximately 2.5 inches of WC.

### 3.3 Installation at Home #22

The initial site visit for home #22 was also performed on September 13, 2012. The inspection revealed a full-height (approximately 8 feet-high) L-shaped basement beneath the original footprint of the house (Figure 3). Like home #21, the foundation walls appeared to be poured concrete and were matched with a contiguous concrete pad that covered the entire basement. Only one small opening was noted in the floor for a dry sump in the southwest corner of the basement. The basement did not have any internal partitions or framed areas (i.e., it was a single large room). The furnace and hot water tank were located near the north wall of the basement with the main electrical breaker box located in the southeast corner. The home did not have any attached crawl spaces, but did have an addition built over an adjacent slab on grade east of the garage. The addition, an entryway for the home, was not occupied on a regular basis; however, the space was open to the main home and, thus, was included in the mitigation design.

Pre-installation communication testing was performed using four vacuum monitoring locations, designated VM-1 through VM-4, positioned within the main basement with VM-1 used as the vacuum extraction point for the test (Figure 3). The vacuum was applied to the subsurface and measured using the same equipment and procedures as those detailed above. Vacuum measurements ranged between -0.009 and -0.040 inch of WC at VM-4 and VM-3, respectively, showing that there was vapor communication beneath the entire basement floor. No communication testing was performed for the entryway, which was part of the living space for the home. WSP assumed that construction beneath this portion of the house would have a similar response to that of the main basement.

#### 3.3.1 System Design and Testing

The vapor mitigation system designed for home #22, based on the communication testing results included two vacuum extraction points: EP-1, located in the main basement, and EP-2, installed at ground level through the concrete floor of the garage. Extraction point EP-2 was designed to generate a vacuum beneath the adjacent slab-on-grade entryway, but was located in the garage (instead of through the entryway itself) to minimize the impact to the homeowners (Figure 3). Both extraction points were created by coring 5-inch diameter holes through the concrete slab, constructing 4-inch ID extraction point risers fitted with PVC gate valves and manometers using the

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same techniques as those listed for home #21. The risers were manifold together using 4-inch ID PVC vapor extraction piping that passed through the north wall of the basement into the garage. The vapor extraction pipe was then routed to the ceiling of the garage where it was connected to the Fantech HP Series Model 220 in-line fan and vented through a vertical stack penetrating the roof. Electrical power for the fan was supplied by a dedicated electrical breaker in the circuit panel located in the southeast corner of the basement. Switches for the fan were mounted in the garage to prevent accidental shut-down of the system.

Post-installation testing of the system was conducted on June 18, 2013 by opening the extraction point valves, turning on the fan, and running the system continuously for approximately 15 minutes to establish the sub-slab vacuum field. WSP installed three additional vacuum measurement points (beyond those used for the pre-installation testing) to verify: that the Plexiglas cover installed over the sump had sealed the opening (VM-7); that the vacuum field extended to the northwest corner of the basement (VM-5); and that the second riser installed in the garage was effective at generating a vacuum field beneath the adjacent slab-on-grade entryway (VM-6; Figure 3). The vacuum measurements indicated good response with vacuums ranging between -0.017 and -0.28 inch of WC for the main basement, and -0.027 inch of WC for the slab-on-grade entryway. Differential pressure readings at the extraction points indicated that the system was generating a vacuum of approximately 2.5 inches of WC.

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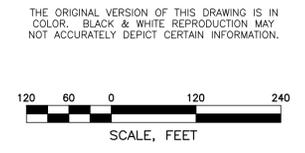
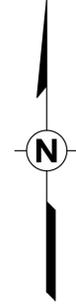
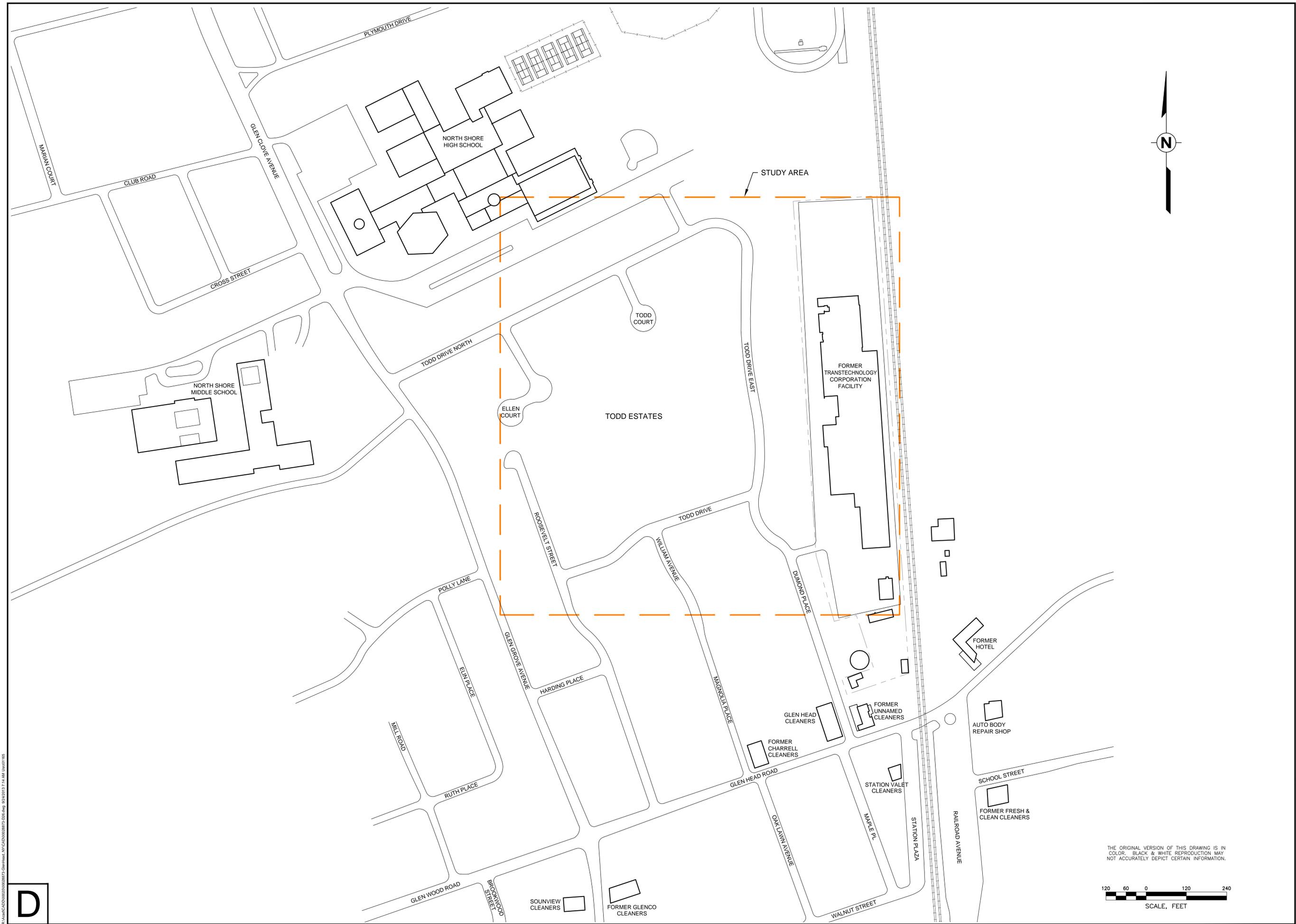
## 4 Summary and Ongoing Obligations

The vapor mitigation system construction activities for both homes were completed on June 18, 2013, after installing the epoxy coating to the basement floors. The systems are currently operating as designed depressurizing the entire sub-slab surface beneath each home. Both homeowners were shown how to read the manometer to verify that the system was operating normally and provided a list of contacts should the system become damaged or otherwise require repair.

As indicated in the *Work Plan for Installation of Vapor Mitigation Systems*, the vapor mitigation system will be inspected annually and maintenance will be performed, as appropriate, to ensure that the system continues to operate satisfactorily. The annual inspection visits will be coordinated with the ongoing sub-slab and indoor air monitoring performed in the nearby homes where chlorinated VOCs were detected, but at a level that only warranted continued monitoring. All routine and non-routine operational monitoring and maintenance activities, the annual inspection logs, and the results of the annual vapor monitoring will be documented and reported to the departments.

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# Figures



REV	REVISIONS	DESCRIPTION

SEAL

DATE

DRAWN BY: *RS O'NEILL*

CHECKED: *RS O'NEILL*

APPROVED: *RS O'NEILL*

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**STUDY AREA**

**FORMER TRANSTECHNOLOGY CORPORATION FACILITY**  
 GLEN HEAD, NEW YORK

PREPARED FOR:  
 BREEZE-EASTERN CORPORATION  
 WHIPPANY, NEW YORK

**WSP**

WSP USA Corp.  
 5 Sullivan Street  
 Cazenovia, New York 13035  
 (315) 655-3900  
 www.wspenvironmental.com/usa

**FIGURE 1**

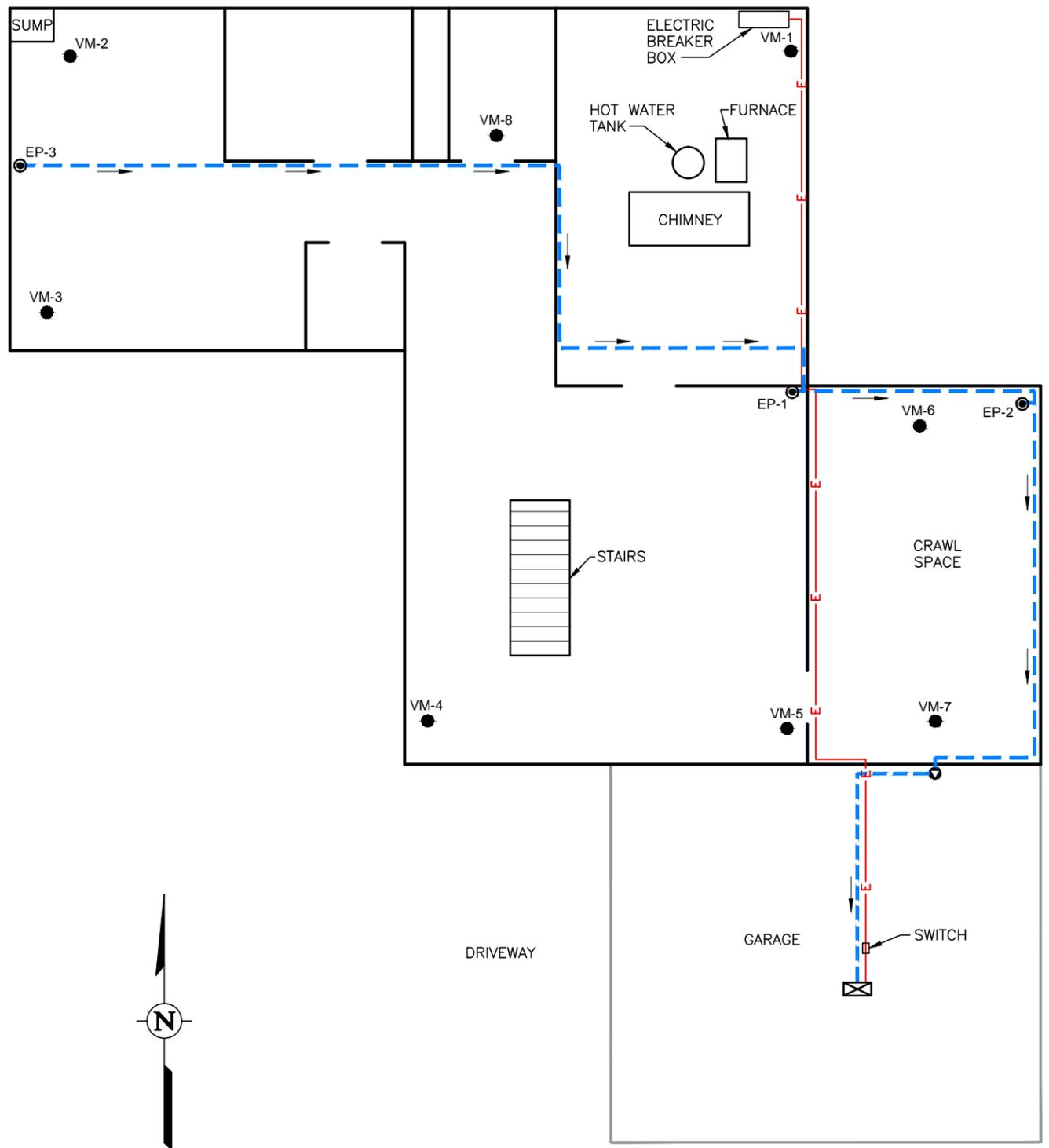
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**D**

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**B**



**PLAN VIEW**  
NOT TO SCALE

**LEGEND**

- SUB-SLAB EXTRACTION POINT (4-INCH TYPICAL)
- VERTICAL PIPE FROM BASEMENT TO GARAGE (4-INCH TYPICAL)
- TEMPORARY VACUUM MONITORING LOCATION
- ⊠ ATTIC-MOUNTED FAN WITH VERTICAL EXHAUST STACK
- VAPOR EXTRACTION PIPING (4-INCH TYPICAL)
- E- ELECTRIC CABLE
- AIR FLOW DIRECTION
- NM NOT MEASURED
- WC WATER COLUMN

**NOTE:**

LOCATIONS FOR ALL SYSTEM COMPONENTS, INTERIOR BUILDING DETAIL, AND VACUUM MONITORING LOCATIONS ARE BASED ON FIELD MEASUREMENTS AND ARE APPROXIMATE.

VACUUM MONITORING LOCATION	COMMUNICATION TEST RESULTS PRE-INSTALLATION (INCHES OF WC)	COMMUNICATION TEST RESULTS POST-INSTALLATION (INCHES OF WC)
VM-1	-0.406	-0.406
VM-2	-0.021	-0.460
VM-3	-0.154	NM*
VM-4	-0.014	-0.114
VM-5	VACUUM POINT	-0.245
VM-6	NM	-0.417
VM-7	NM	-0.097
VM-8	NM	-0.145

\* HOMEOWNER USED SPACE FOR STORAGE AND POINT WAS INACCESSIBLE.

THE ORIGINAL VERSION OF THIS DRAWING IS IN COLOR. BLACK & WHITE COPIES MAY NOT ACCURATELY DEPICT CERTAIN INFORMATION.

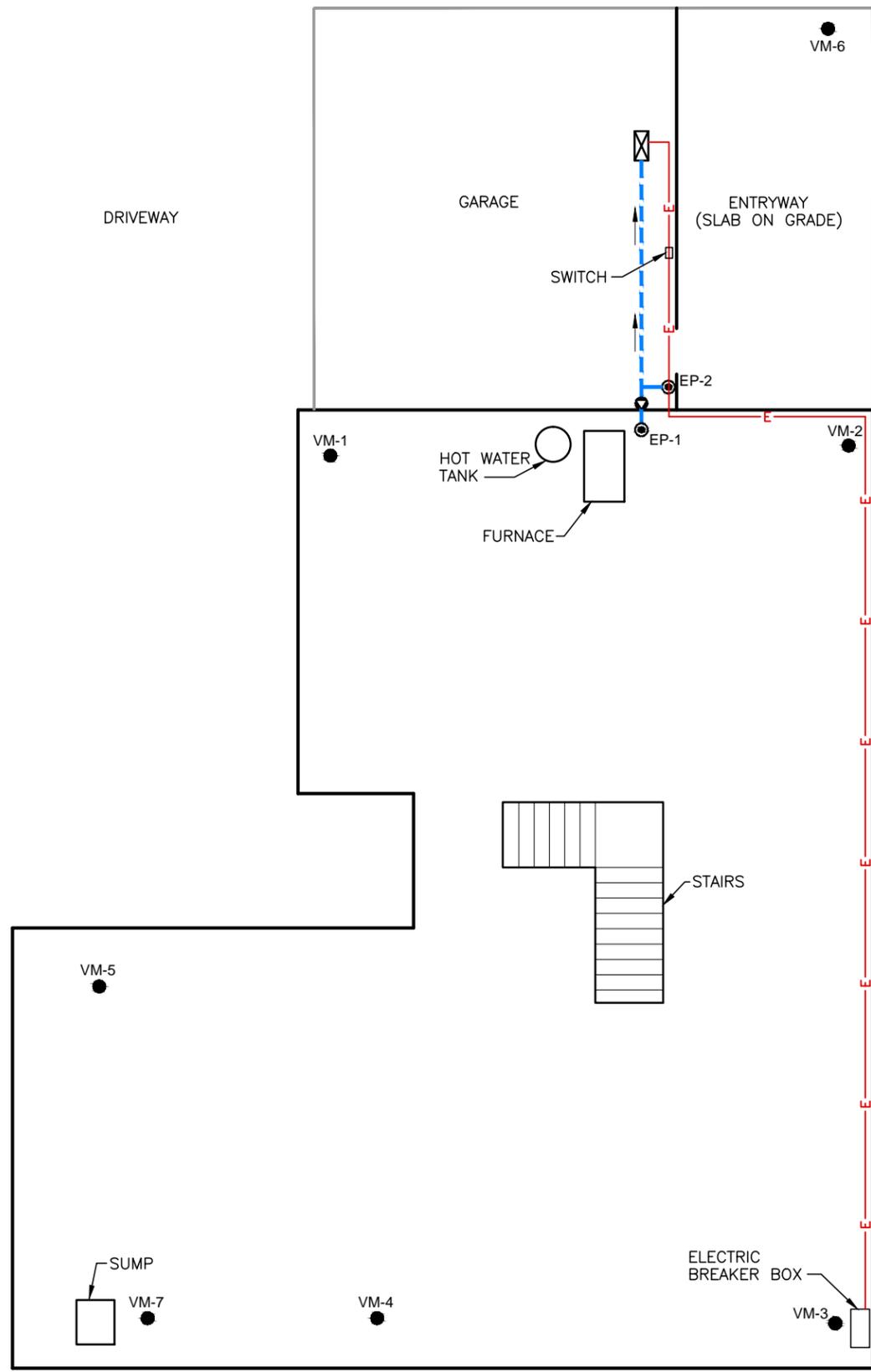
Drawn By: *RF 09242013*  
 Checked: *DB 09242013*  
 Approved: *KAS 09242013*  
 DWG Name: 00028873-B18

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 GLEN HEAD, NEW YORK  
 PREPARED FOR  
 BREEZE-EASTERN CORPORATION  
 WHIPPANY, NEW YORK

**FIGURE 2**  
**AS-BUILT VAPOR MITIGATION SYSTEM**  
**HOME #21**

WSP USA Corp.  
 5 Sullivan Street  
 Cazenovia, New York 13035  
 (315) 655-3900  
 www.wspenvironmental.com/usa

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**PLAN VIEW**  
NOT TO SCALE

**LEGEND**

- SUB-SLAB EXTRACTION POINT (4-INCH TYPICAL)
- ▼ VERTICAL PIPE FROM BASEMENT TO GARAGE (4-INCH TYPICAL)
- TEMPORARY VACUUM MONITORING LOCATION
- ⊠ ATTIC-MOUNTED FAN WITH VERTICAL EXHAUST STACK
- VAPOR EXTRACTION PIPING (4-INCH TYPICAL)
- E— ELECTRIC CABLE
- AIR FLOW DIRECTION
- NM NOT MEASURED
- WC WATER COLUMN

**NOTE:**

LOCATIONS FOR ALL SYSTEM COMPONENTS, INTERIOR BUILDING DETAIL, AND VACUUM MONITORING LOCATIONS ARE BASED ON FIELD MEASUREMENTS AND ARE APPROXIMATE.

VACUUM MONITORING LOCATION	COMMUNICATION TEST RESULTS PRE-INSTALLATION (INCHES OF WC)	COMMUNICATION TEST RESULTS POST-INSTALLATION (INCHES OF WC)
VM-1	VACUUM POINT	-0.20
VM-2	-0.010	-0.28
VM-3	-0.040	-0.030
VM-4	-0.009	-0.020
VM-5	NM	-0.037
VM-6	NM	-0.027
VM-7	NM	-0.017

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**B**

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FORMER TRANSTECHNOLOGY CORP. FACILITY  
 GLEN HEAD, NEW YORK  
 PREPARED FOR  
 BREEZE-EASTERN CORPORATION  
 WHIPPANY, NEW YORK

FIGURE 3  
 AS-BUILT VAPOR MITIGATION SYSTEM  
 HOME #22

**WSP**  
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