Vapor Intrusion Investigation Work Plan

Former Northwoods Laundry Site
405 Front Street
Minocqua, Wisconsin

WisDOT #0656-50-31
BRRTS #02-44-000517

March 2018

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Prepared for the
Wisconsin Department of Transportation

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Section 1
Introduction

1.1 Background

The former Northwoods Laundry property (Site) is located at 405 Front Street in Minocqua, Wisconsin. The property is a Wisconsin Department of Natural Resources (WDNR) Bureau for Remediation and Redevelopment Tracking System (BRRTS) contaminated property with case activity number #02-44-000517. Historical dry cleaning activities from the 1970s to 1992 at the former Northwoods Laundry property caused soil and groundwater contamination in the form of chlorinated volatile organic compounds (CVOCs), primarily trichloroethene (TCE) and tetrachloroethene (PCE). The Wisconsin Department of Transportation (WisDOT) became responsible for the environmental liability at the Site when it acquired a portion of the property for USH 51 construction activities in 1995.

A 1993 Phase 2 investigation detected PCE within the soil in the proposed USH 51 ROW at the Site. In 1994, a Phase 2.5 investigation was completed at the site and determined that CVOC soil impacts were limited to the upper five feet of soil at the Site, and that groundwater had also been impacted by CVOCs. An additional subsurface investigation was performed in 1996 to further define Site contamination in order to complete a remedial action.

In 1996, approximately 350 tons of PCE-impacted soils were excavated and treated off-site by incorporation in asphalt. Following source removal, the Northwoods Laundry BRRTS site #02-44-000517 was granted closure on October 2, 1996. However, due to detections of CVOCs in groundwater at adjacent BRRTS sites (Z-Best Auto Detailing, #03-44-001150 and Concord Minocqua East/Site 3, #03-44-000829), the Northwoods Laundry BRRTS site was reopened by WDNR on September 28, 1998.

Additional soil and groundwater sampling was performed in 2001 as part of a Phase 3 investigation to define the nature and extent of PCE and TCE in groundwater.

In May 2017, TRC Environmental Corporation (TRC), on behalf of the WisDOT, installed 15 small diameter groundwater monitoring wells to collect off-site downgradient groundwater samples. Based on the groundwater CVOC plume extents as defined by the 2017 sampling, the WisDOT requested a vapor intrusion assessment of the former Northwoods Laundry site and surrounding properties as part of the case closure efforts for the Northwoods Laundry BRRTS site.

1.2 Purpose and Scope

TRC, on behalf of the WisDOT, offers this screening assessment and work plan to conduct vapor/air sampling to evaluate the potential pathways for vapor intrusion at the former Northwoods Laundry property and surrounding properties, in accordance with WDNR guidance documents (WDNR 2014, WDNR, 2018). The materials presented in the WDNR guidance documents and select standard operating procedures (SOP) (Appendix A) provided by TRC and Cox-Colvin Vapor Pin® have been used in the preparation of this screening assessment and work plan. The purpose of this evaluation is to identify which on- or off-site receptors may be at risk for vapor intrusion and to determine appropriate responses to the sampling results.

This vapor intrusion evaluation began with obtaining permission from select property owners to access offsite properties and complete a site walk/initial non-invasive assessment to finalize sampling details for this work plan. Further investigative work will include the initial vapor intrusion monitoring activities, and initial sampling and analytical results will determine additional activities, if needed. The intent of this work plan is to be used for the initial and supplemental vapor intrusion monitoring activities, and notifications/amendments to this plan will be provided to the WisDOT and WDNR as needed.

Section 2
Site Conditions

A site description, geologic setting, and hydrogeology for the Site, are summarized in this section to provide a framework for the site conceptual model for vapor migration.

2.1 Site Summary

2.1.1 Site Location

The former Northwoods Laundry property is located at 405 Front Street in the Town of Minocqua, Oneida County, Wisconsin (SE ¼ of the NW ¼ of Sec. 14, Township 39 North, Range 6 East).

2.1.2 Site Description

The Site is bordered to the west/north by Chippewa Street (USH 51) with Menominee and Milwaukee Street to the east and south. Land use surrounding the Site is a mixture of residential and commercial properties. Commercial properties are primarily located around the Site but some residential properties are mixed in to the west and south of the Site. The Site is bordered to the north/west by multiple BRRTS sites which include: The Concord Minocqua East/Site 3 (BRRTS #0344000829), Concord Inn (Former) (BRRTS #0244000032), Concord Inn (BRRTS #0244000250) and Z-BEST Auto Detailing (BRRTS #0344001150).

2.2 Physiographical and Geological Setting

2.2.1 Site Topography

The Town of Minocqua is primarily surrounded by Minocqua Lake and adjacent connecting lakes. The area is similar to an island with the highest elevation generally being found near the central portion and the Northwoods Laundry Site is located just east of that location. The terrain slops in all directions toward the surrounding lake (Figure 1).

2.2.2 Site Geology

The geology in the Minocqua area is dominated by glaciofluvial deposits from the Wisconsinan age. The sandy aquifers in this area consist of glacial outwash and are characterized by high hydraulic conductivity. Based on the Phase 2.5 subsurface investigation completed in May 2017, the surface of the former Northwood's Laundry property is covered by a portion of USH 51 and loose gravel and grass. Soils near the property and in the areas where groundwater impacts are found above the NR 140 enforcement standards (ES) for PCE and TCE consist of three separate unconsolidated units. A shallow fill consisting of poorly graded fine silty sand with little amounts of gravel present; a fine sand unit; and a fine grained silty sand with intermittent silty clay laminations. Bedrock was not encountered during this investigation, but is estimated to be greater than 50 feet below the ground surface.

2.2.3 Site Hydrogeology

The investigation area is underlain by an unconfined aquifer approximately 18 feet below ground surface. The aquifer is estimated to be greater than 50 feet thick. Based on the 2017 investigations, groundwater depths were found to be between 13 and 18 feet below ground surface with an overall average depth of 17 feet. The groundwater flow direction is generally west to northwest with an approximate horizontal gradient of 0.0003 ft/ft from upgradient well TRC-TW-2 (Figure 2) to downgradient well TRC-TW-11 (Figure 2). Hydraulic conductivity of the soils within the investigative area were not measured during the 2017 investigation, but were estimated to be 6.00×10^{-3} cm/sec at the adjacent Z-Best Auto BRRTS site (ECCI, 2002).

2.3 Groundwater and Soil Impacts

2.3.1 Groundwater Impacts

Groundwater monitoring results obtained in May and December 2017 indicate that CVOCs are currently present at and down gradient of the Site. The PCE and TCE plume extends from the site to the west/north west. PCE was also observed to the south of the Site in a sidegradient well located at the intersection of Milwaukee and Chippewa Street. Concentrations of PCE to the west/northwest were detected above the NR 140 ES and to the south above the NR 140 preventative action limit (PAL). TCE impacted groundwater above the NR 140 ES was detected to the west of the Site, but was not detected in the wells to the north or south of the Site. Figure 2 and 3 show the extents of the impacted groundwater above the NR 140 ES for PCE and TCE, respectively. In addition, breakdown products cis-1, 2 dichloroethene and vinyl chloride were detected at two down gradient wells (TRC-TW-7 and TRC-TW-8) above the NR 140 ES and/or PAL.

2.3.2 Soil Impacts

Multiple soil removals associated with the reconstruction of USH 51 were completed at the Site. As documented in the 1996 Remedial Documentation Report (RMT, 1996), a limited portion of the Site may still contain soil impacted with PCE at concentrations above the NR 720 protection of groundwater pathway residual contaminant level (RCL). Impacted soil was documented at shallow depths between ground surface and five feet below ground surface (bgs). The approximate extents of the impacted soil are shown on Figure 4 based on historic data. However, the extents were adjusted based on data being collected prior to USH 51 reconstruction. Extents shown assume that shallow impacts were likely removed during reconstruction activity. CVOC soil contamination was also documented further west near the Z-Best Auto Detailing site (BRRTS #03-44-001150) at depths near the water table (ECCI, 2002). The extents of this contamination are not included in Figure 4 but are likely representative of impacted soils in the smear zone due to water table impacts.

Section 3
Vapor Intrusion Pathway Screening Assessment

TRC completed a vapor pathway screening assessment on behalf of the WisDOT to determine if properties near the former Northwoods Laundry Site located at 405 Front Street, Minocqua, Wisconsin (BRRTS # 02-44-000517) would warrant an invasive vapor intrusion evaluation. This pathway screening is necessary to determine if there is the potential for vapor intrusion on or off the subject property. Based on historical information, and recent detections of CVOCs in sidegradient well TW-5, other sources may be contributing to the CVOC impacts in the groundwater. The following discussion and assessment is based on data collected in 2017 and review of historical investigative information.

3.1 Vapor Intrusion Screening Criteria

The WDNR (2018) recommends that vapor intrusion be evaluated at almost all sites containing soil and/or groundwater impacted with CVOCs. CVOCs in the environment are mobile as a vapor or dissolved in groundwater and generally cannot be detected by their odor at concentrations presenting a human health risk. CVOCs migrating as a vapor may accumulate beneath buildings on the source site (on-site) and off-site properties. In addition, the results of an on-site investigation do not rule out off-site migration, so both the source area and potential off-site receptors must be evaluated. The actual extent of potential for vapor intrusion from impacted soil and/or groundwater is dependent on multiple factors (i.e. soil type, moisture, water level variations, constituents of concern, etc.) which can influence which properties are at risk. In general, the vapor intrusion investigation begins at properties near the CVOC source area and then outwards based on investigative results, potential receptors, extent of permeable surfaces, etc. The WDNR recommends that an invasive vapor intrusion evaluation be completed for CVOC sites if any of the following conditions exist on-site or off-site (Section 3.4.2 WDNR 2018):

- A building or undeveloped property is present over or within 100 feet of CVOC impacted soil;
- A building overlies groundwater with CVOC concentration above the Wis. Admin, NR 140 ES at the water table. Note when groundwater contamination is deep and the water table is clean, the clean water prevents the migration of vapors into the vadose zone;
- Groundwater with concentrations above the Wis. Admin NR 140 PAL has entered the building or is in contact with the building's foundation; and/or
- A utility line transects a CVOC source area.

3.2 Northwoods Laundry Site Screening Assessment

Overall TRC completed a screening assessment to determine if any of the criteria listed in Section 3.1 warrants a more invasive vapor intrusion pathway evaluation at the Site. Overall 16 parcels located on or surrounding the source property were assessed. For discussion purposes, TRC has identified the 16 parcels with a unique property identification number which are summarized in Table 1 and shown on Figures 5. The below discussion includes a summary of each WDNR screening criteria with respect to the Northwoods Laundry Site.

- ***A building or undeveloped property is present over or within 100 feet of CVOC impacted soil;***

  As discussed in Section 2.3.2, PCE impacted soil at levels above the NR 720 RCL for groundwater pathway may be present near the Site. However, based on the extents, depth, and concentrations of PCE documented in the soil, TRC does not recommend that a further invasive vapor intrusion evaluation be required based on soil contamination alone.

- ***A building overlies groundwater with CVOC concentration above the Wis. Admin, NR 140 ES at the water table;***

  Results from the 2017 groundwater monitoring, indicate that groundwater below a number of the properties assessed contains PCE and TCE at concentrations above the NR 140 ES. The current extents of impacted groundwater are shown on Figures 2 and 3. Overall, the plume with ES exceedances extends under 15 of the 16 properties. However, based on each property's use, the presence or absence of buildings, and the CVOC plume extents, TRC recommends that a more invasive vapor intrusion evaluation be completed at 9 of the properties as shaded in orange on Figure 5.

- ***Groundwater with concentrations above the Wis. Admin NR 140 PAL has entered the building or is in contact with the building's foundation;***

  Groundwater depths recorded in 2017 ranged between 13 and 18 feet bgs with an average depth of 17 feet. This depth would indicate that groundwater has likely not entered and is not in contact with surrounding building foundations. TRC recommends only the 9 properties within the limits of impacted groundwater above the NR 140 ES for TCE and PCE be included in the invasive vapor intrusion evaluation at this time.

- ***A utility line transects a CVOC source area.***

  Based on the extensive invasive vapor intrusion evaluation warranted by NR 140 ES groundwater plume exceedances, TRC does not recommend additional properties be evaluated based on utilities alone.

TRC has reviewed the Site-specific information along with the WDNR screening criteria and have concluded that a more invasive evaluation must be completed to assess the potential vapor intrusion pathway at nine properties to the west/northwest and directly east of the former Northwoods Laundry building. These conclusions have been made based on the extents of impacted groundwater above the NR 140 ES for PCE and TCE. Figure 5 includes a summary of the properties that will be evaluated.

3.3 Property Site Walk Summary

Based on the initial screening assessment, TRC completed an initial site walk of the properties warranting an invasive vapor intrusion evaluation. Between January 31 and February 1, 2018, TRC performed walk-throughs of the properties to further evaluate the risk of vapor intrusion from the identified groundwater contaminants and determine where vapor sampling should be completed. A summary of each property is included in this section as a reference for this work plan. The locations of each property are shown on Figure 5 with respect to the former Northwoods Laundry. Note that site walks were not completed at properties 15 and 16 based on the defined limits of the impacted groundwater.

3.3.1 Properties 1-3

Properties 1 and 2 consist of the parcels where the former Northwoods Laundry building was located (405 Front Street). Property 3 is located to the east of the former buildings. All three parcels are owned by the same person but no property addresses are listed in tax documents. An abandoned garage is present within the limits of Property 3 and contains a slab constructed on grade with a footprint of approximately 557 square feet (sq ft). The building contains a concrete floor and block and mortar wall structure. The windows and multiple doors for the building are broken out and multiple holes were observed in the roof. The building does not appear to be inhabited or used currently. The property extents and further Site information are shown on Figure 6.

3.3.2 Properties 4-5

Properties 4 and 5 are located to the west of the Site and consists of the former Z-BEST Auto Detailing site (BRRTS #0344001150) (Figure 7). Property 4 contains one residential home (515 Chippewa Street) with a 420 sq ft lower level. The floor is primarily concrete and two crawl spaces were observed along the west and south wall of the lower level. Property 5 (329 E Front Street) contains a building approximately 1,238 sq ft in size. The building contains a concrete slab constructed on grade which consists of two garage spaces, a storage room, a utility room, and an office with a bathroom. It appears there is a third garage stall to the south but access was not available while onsite. A tenant currently occupies the buildings seasonally and the properties are currently for sale.

3.3.3 Properties 6-8

Property 6 is currently used as an access driveway for the adjacent properties 7 and 8. Property 7 (321 Front Street) consists of one building that contains a small lower level approximately 229 sq ft in size. The lower level contains one sump pit but according to the owner no water enters the area. Two crawl spaces were observed to the north and south of the lower level limits. Property 8 (313, 315, and 317 Front Street) has two main lower levels as shown on Figure 7. The lower level for 313 Front Street is approximately 293 sq ft and contains a concrete floor. The lower level for 315 and 317 Front Street are connected and contain three rooms as shown on Figure 7. The room within 315 Front Street is approximately 293 sq ft and consists of a concrete floor. The lower level for 317 Front Street consists of two rooms. One room contains a concrete slab with a 453 sq ft footprint. This room along with 315 Front Street appear to be the same slab. An older slab is also present within 317 Front Street and according to the owner was a part of the original lower level before the building burned down and was reconstructed. This portion of the lower level is approximately 308 sq ft.

3.3.4 Properties 9 - 10

Properties 9 and 10 consist of multiple small commercial businesses but contain only one joined lower level. The lower level is approximately 2,985 sq ft in size and contains concrete and dirt floors as shown on Figure 8. The walls are constructed out of cobble and mortar and there is one crawl space observed along the eastern wall.

3.3.5 Property 11

Property 11 consists of multiple small commercial businesses but contains only one small lower level (Figure 9). The lower level is approximately 361 sq ft in size and one sump crock was observed with a dirt bottom. The owner noted the only water issues they have encountered, was believed to be from surface water running down the lower level wall. Based on the depth of the lower level and groundwater elevations near the property, groundwater entering lower level was unlikely.

3.3.6 Property 12

Property 12 contains a pavilion area which includes two bath rooms as shown of Figure 9. There is an additional room that TRC did not have access to during the site walk. Additional details are shown on Figure 9, but based on the building location with respect to the impacted groundwater further invasive sampling is not recommended at this property.

3.3.7 Property 13

Property 13 consists of one single level building that contains a slab constructed on grade (Figure 10). The foot print of the building is approximately 1,266 sq ft and contains a tiled floor throughout.

Section 4
Vapor Intrusion Pathway Investigation

The WisDOT requested TRC complete a vapor intrusion assessment of the Site and surrounding properties as part of case closure efforts. An initial background review of the former Northwoods Laundry Site and surrounding properties was completed. In addition, the most recent groundwater monitoring data from 2017 was reviewed. A vapor intrusion screening assessment was completed as discussed in Section 3. The screening assessment selected nine properties adjacent to the Site as potentially requiring an invasive vapor intrusion pathway evaluation. The number of properties chosen for the proposed evaluation are based on the extent of the CVOC groundwater impacts with concentrations above the NR 140 ES and have a potential preferential pathway where vapor intrusion may be present. Any subsequent vapor intrusion investigations will be conducted in a stepwise fashion as more data is collected and interpreted, and the site conceptual model is revised.

4.1 Invasive Vapor Intrusion Evaluation

Invasive vapor intrusion pathway evaluations are completed by collecting various types of samples to assist in determining if a risk is present and if a vapor mitigation system or equivalent remedy is required. The potential for vapor intrusion can be monitored using various methods which are dependent on the property being investigated and information generally obtained from the source site investigations. The type (commercial, industrial, or residential), use, and size of each property will determine how vapor intrusion is assessed and what vapor sampling methods will yield a representative assessment.

4.1.1 Sampling Types

A typical vapor intrusion assessment requires samples to be collected from below the sub-slab of a building, from the indoor air, and from the outdoor air. The number and type of samples collected is dependent on the property type. A general description of each sample type as applicable to this work plan and the Site investigation are:

- Sub-slab vapor monitoring – generally refers to the monitoring of vapor concentrations present below the floor (i.e. concrete slab) of a structure to characterize the degree and extent of vapors present;
- Indoor air monitoring – generally refers to the monitoring of air quality within a room or enclosure of a structure. These samples are used to determine if a vapor intrusion pathway is present and if a mitigation system or remediation is required; and

- Outdoor air monitoring – generally refers to ambient air quality monitoring outside of a structure or area of concern. The WDNR (2018) recommends that outdoor air samples should be collected when indoor air monitoring is completed.

In general, properties are investigated to determine if sub-slab vapors for constituents of concern at elevated levels are present below the slab of the structure being investigated. Indoor and outdoor air monitoring are dependent on the property being investigated.

4.1.2 Sub-Slap Vapor Intrusion Monitoring

The properties located at and adjacent to the Site consist of predominately small commercial buildings with one residential home (used only for storage currently) and one abandoned garage. Based on the structures currently constructed at and near the Site, discrete sampling methods are recommended for the vapor intrusion evaluation.

The discrete sampling method is generally used in smaller facilities (small commercial and/or residential properties) and represent a more limited area. The number of discrete samples is dependent on the square footage of the lower level of the buildings or main level if a slab is constructed on grade with no lower level. The location of the samples (with respect to this work plan) is dependent on the building type, layout and proximity to the delineated groundwater impacts. The WDNR recommends three sample locations for buildings with a footprint of 5,000 sq ft and an additional location for every additional 2,000 sq ft (WDNR 2014). For residential properties, one sub-slab discrete sample within the central portion of the residence is typically sufficient. The WDNR recommends two sample locations if a residence footprint exceeds 1,500 sq ft (WDNR 2014).

4.1.3 Indoor/Outdoor Air Monitoring

It is important to determine if vapors have already migrated to the indoor air and pose an immediate risk to occupants. For small commercial and residential properties, a sample of the indoor air is generally collected and laboratory analyzed. These samples are collected during an 8-hour or 24-hour period (depending on the property type) prior to the collection of the sub-slab sample. Indoor air monitoring is not required to be completed prior to an initial sub-slab investigation but is highly recommended by the WDNR for residential and select commercial properties depending on the layout and use. The collection of an indoor air sample immediately preceding a sub-slab sample provides critical information to determine if a property owner is at risk due to vapor intrusion. An outdoor air sample is collected at the building location(s) concurrently with the indoor air for comparison purposes.

4.2 Property Access and Property Assessments

Property access agreements and property assessments are integral to conducting a successful vapor intrusion investigation. Currently TRC and the WisDOT have signed access agreements to subject properties included in this initial vapor intrusion evaluation. The agreements provided to each owner outlined the Site's background and proposed evaluation along with technical documents provided by the WDNR. In addition, all owners were provided contact information for TRC, the WisDOT, and the WDNR.

Between January 31 and February 1, 2018, TRC completed a site walk of each subject property to better understand each property's type, layout, use, and obtain applicable construction information. Information collected during these site visits has been used for this work plan to evaluate vapor intrusion pathways. A summary of each property is included in Section 3.3 as part of the vapor intrusion assessment.

4.3 Proposed Properties for Initial Vapor Intrusion Assessment

The buildings listed below have been selected for the initial invasive vapor intrusion evaluation as discussed in the vapor intrusion screening assessment (Section 3.3). Figure 5 illustrates the location of each property with respect to the Site and Table 1 includes relevant property information. As discussed, these properties were selected based on proximity to known extents of the CVOC impacts in groundwater and historical Site investigative information. Additional properties may be included in later phases of the closure process as the extent of vapor intrusion impacts are further delineated. Properties include:

- One abandoned garage building located east of the former Northwoods Laundry building location;
- Seven small commercial buildings to the west-northwest of the Site along Front Street (Note some properties include multiple business but generally have individual or shared lower levels if present); and
- One residential property to the west of the Site.

As discussed above, the smaller commercial and residential buildings are anticipated to be assessed using discrete sample locations. In keeping with WDNR (2018) guidance, no soil gas samples will be collected during this initial assessment as sub-slab samples are preferred on properties with existing structures. The need for soil gas samples on empty lots is not recommended at this time and not included as a sampling method in this work plan. Table 1 and Figures 5 through 10 show the buildings that will be included in this evaluation. In addition, the extents of each building's foot print (lower level if present) and the estimated number of samples to be collected are included.

Section 5
Residential/Small Commercial Sampling

Sub-slab sampling using Cox-Colvin® Vapor Pins® (Vapor Pins®) are proposed to be conducted at the small commercial and residential buildings near the Site. One sub-slab sample point will be constructed through the concrete slab of the lower level of the residential property. In addition, the small commercial properties will use similar methods to the residential monitoring with one or multiple Vapor Pins® installed based on the foot print of the subject property. It is anticipated that two properties based on layout and square footage will require up to three discrete sample points and the other properties will be limited to one sample point. The sampling methods outlined in this work plan will be completed per guidance provided by the WDNR (2014, 2018).

5.1 Indoor Air Sampling

Indoor air sample(s) will be collected from the lower level of each residence and from the lower level or main level for the small commercial buildings (depending on construction) prior to the installation of the sub-slab sample point. Each indoor air sample will be collected using a 6-liter SUMMA® canister with 24-hour regulator. Each SUMMA® canister will be submitted to the laboratory for EPA Method Toxic Organic (TO) -15 analysis for a select list of CVOCs to include: PCE, TCE, cis-1,2 dichloroethene, trans-1,2 dichloroethene, and vinyl chloride.

Based on the property site walks completed in January and February 2018, TRC recommends that 10 indoor air samples be collected. Table 1 and Figures 5 through 10 identify the target properties along with the approximate location of each sample.

5.2 Background (Outdoor) Sampling

In concurrence with indoor air monitoring, a background ambient air sample will be collected near the properties being investigated which will provide additional information about air quality surrounding the buildings (Section 5.4.4 WDNR 2018). Background samples will only be collected when indoor air monitoring is being completed. Each outdoor air sample will be collected using a 6-liter SUMMA® canister with 24-hour regulator. Each SUMMA® canister will be submitted to the laboratory for TO-15 analysis for a select list of CVOCs to include: PCE, TCE, cis-1,2 dichloroethene, trans-1,2 dichloroethene, and vinyl chloride.

Based on the proposed schedule (discussed in Section 5.4 below) for indoor air monitoring, a total of two background samples will be collected per event. One sample will be collected between the first and second day of the evaluation and the approximate location is shown on

Figure 7. A second sample will be collected between the second and third day of the evaluation when indoor air canisters and the approximate location is shown on Figure 10. This sampling criteria will be completed during each vapor intrusion evaluation event unless changes to the sampling schedule are required.

5.3 Sub-slab Sampling

Based on the property site walks completed in January and February 2018, TRC recommends that 12 sub-slab samples be collected with one duplicate as a quality control measure. Table 1 and Figures 5 through 10 identify the target properties along with the approximate location of each sample.

5.3.1 Sample Point Construction

Each sub-slab sample point will be constructed using Vapor Pin® equipment provide by Cox-Colvin & Associates, Inc. The Vapor Pin® will be installed according the manufacture's Standard Operating Procedure (SOP) (Appendix A). In general, the Vapor Pins® will be constructed through the floor of the lower level or main level (if slab on grade) for each of the small commercial or residential properties. A hammer drill will be used to bore a 5/8" hole through the slab of the building and a Vapor Pin® with silicone sleeve will be constructed in the bore hole. TRC will use a vacuum with a HEPA filter during all drilling work as a dust control measure. The Vapor Pin® will be constructed as flush mount points when possible and left in place following sampling, pending the results of the vapor sampling. If the concrete slab contains sufficient thickness and a flush mount construction is applicable, TRC will counter bore the 5/8" hole with a 1-1/2" bore to allow for the Vapor Pin® to be constructed slightly below the slab surface. All Vapor Pin® sampling points installed will be abandoned at a later date once it is determined that additional vapor samples are not needed.

5.3.2 Leak Testing

The sample ports will be directed away from cracks, sumps, or other features that could introduce indoor air into the sub-slab vapor. Leak tests to monitor the port seal integrity prior to sampling will be performed using the water dam approach and a helium shroud/tracer test. In addition, the sampling canister and associated connections (sample train) will be tested through use of a shut-in test. For all the tests, if a leak is detected, corrective action will be taken to eliminate the leak prior to initiating collection of the sample.

Water Dam Test

The water dam test is a method in which a shroud or counter-sunk hole is installed around the Vapor Pin®. The shroud/counter sunk hole is filled with a small amount of water and monitored for drainage. If the water maintains a constant level and no draining is visually observed, the port has been sealed appropriately. An SOP for the water dam test provided by Cox-Colvin and Associates, Inc. is included in Appendix A of this work plan.

Helium Shroud Test

The helium shroud test consists of sealing a shroud around the Vapor Pin® following installation and prior to sampling. A piece of tubing is connected to the sample port and extended to the exterior of the shroud through a small sealed hole. The shroud is filled with helium until a concentration of 20% to 50% by volume has been introduced into the shroud (measured by a hand-held helium monitor). While the shroud is filled with helium, a sub-slab vapor sample is collected through the section of tubing connected to the sample port using a hand pump. The extracted sample is tested with a hand-held helium monitor and if the concentration of the extracted sample is below 5%, the port is sealed and sampling can be completed (Section III Part B, WDNR 2014).

Shut-In Test

A leak test (shut-in test) will be completed prior to the collection of each sample to test the SUMMA® canister and associated connections (sample train) for potential leaks at the connection points. If a leak is detected, the connections will be tightened and/or reassembled to ensure no indoor air is drawn in during the sub-slab sampling process, after which the shut-in test will be performed again.

5.3.3 Sample Collection and Analysis

Following the leak tests, a sub-slab vapor sample will be collected from each sample point using a 6-liter SUMMA® canister with 30-minute regulator. Each SUMMA® canister will be shipped via common carrier under proper chain-of-custody and submitted to PACE Analytical Laboratory in Minneapolis, MN or equivalent for TO-15 analysis for a select list of CVOCs to include: PCE, TCE, cis-1,2 dichloroethene, trans-1,2 dichloroethene, and vinyl chloride.

5.4 Vapor Intrusion Monitoring Schedule

TRC anticipates that each vapor evaluation as discussed in the above sections will require three field days from completion. During the first onsite field day TRC will set one background (outdoor) sample followed by strategically placing indoor air canisters at select properties. During the second field day, the first background sample will be finished and a second one will be placed and started. TRC will proceed with installing sub-slab samples points and collecting samples from properties where indoor air sampling was completed. In addition, indoor air canisters will be placed in the remaining properties not completed during Day 1. During the third field day, the second outdoor air sample and indoor air samples set the previous day will be shut and sub-slab samples will be collected. Table 2 includes a breakdown of the planned schedule for reference. Based on site access, the schedule may require adjustments as needed.

Section 6
Reporting

Analytical results along with Site and contact information, and pertinent information with regards to the sampling event will be submitted to the property owners, occupants, and WDNR within 10 business days of receipt per Ch. NR716.14(2)(c) (WDNR 2014). The analytical results from the first vapor sampling event will be immediately evaluated upon receipt by TRC. These results will be summarized in an initial letter style report that will be transmitted to WisDOT and the WDNR, along with recommendations for the next course of action to be taken at the Site. The analytical data will be compared to the WDNR established vapor action levels and vapor risk screening levels for indoor air and sub-slab concentrations for constituents of concern. The WI Vapor Quick Look-up Table which is based on November 2017 USEPA Regional Screening Levels Tables will be used for evaluation (Appendix C). Depending upon the results and recognizing that vapors emanating from contaminated soil or groundwater may be from off-site sources, the following courses of action are possible if the CVOC source is attributable to the Northwoods Laundry Site:

- There is no vapor intrusion risk.
  - If results indicate no vapor intrusion risk in a first sampling round (i.e. all analytical results are below the screening levels, additional confirmation round(s) of sub-slab vapor sampling will be recommended (as outlined in this work plan) but will be property specific. For the smaller commercial and residential properties, up to three sampling events may be required and will be completed as outlined in this work plan. One of the sampling events must be completed during conservative conditions, if the initial sampling event is not conducted under conservative conditions (i.e., between November and March). Conservative conditions are during the months of winter and early spring when the ground surface is frozen and snow-covered, or the shallow soils are saturated.
- A vapor intrusion risk is present in one or more of the properties evaluated, and the limits of the area posing a risk have been defined.
  - For smaller commercial and residential properties where the initial investigation determines a risk of vapor intrusion, TRC will discuss with the WisDOT and the WDNR a desired course of action. TRC can recommend the development of a vapor mitigation or remediation plan.
- A vapor intrusion risk is present, but the limits of the area posing a risk have not been defined (i.e. additional properties require investigation based on analytical results).

- Develop an amendment to this work plan for additional vapor sampling (to be included in the initial summary letter following the first monitoring event).
- Develop a vapor mitigation or remediation plan based on the outcome of the additional sampling.

Section 7
References

RMT, Inc. 1996. Remedial Documentation, WisDOT USH 51 Reconstruction Project, Northwoods Laundry, Minocqua, Wisconsin. Prepared by RMT, Inc., Madison, Wisconsin. September 1996.

RMT, Inc. 2002. Phase 3 Investigation Former Northwoods Laundry Minocqua, Wisconsin. Prepared by RMT, Inc., Madison, Wisconsin. January 2002.

ECCI. 2002. Request for Case Close Out for Z-Best Auto Detailing, 329 Front Street, Minocqua, Wisconsin. Prepared by Environmental Compliance Consultants, Inc., Rhinelander, Wisconsin. December 2002.

WDNR. 2014. Sub-Slab Vapor Sampling Procedures. RR-986. July 2014.

WDNR. 2018. Addressing Vapor Intrusion at Remediation and Redevelopment Sites in Wisconsin (RR-800). January 2018.

Table 1
Vapor Intrusion Assessment Monitoring Summary
Former Northwood's Laundry (BRRTS #02-44-000517, WISDOT #0656-50-31)
Minocqua, Oneida County, Wisconsin
TRC Project # 298526.0000.0000

TRC Property ID	Site Address	Site Contact	Lower Level Present	Indoor Air Sample	Sub-slab Vapor Sample
1	***Property does not contains any building/structures, and will not be further assessed.***				
2	***Property does not contains any building/structures, and will not be further assessed.***				
3	405 Front Street	William Schmitz	N	0	1
4&5	515 Chippewa Street	Curtis Trinko	Y	1	1
4&5	329 East Front Street	Curtis Trinko	N	1	1
6	***Property is a drive way between 321 Front Street and 329 East Front Street, no further assessment will be completed at this time.***				
7	321 Front Street	Vic Ouimette	Y	1	1
8	313 Front Street	Vic Ouimette	Y	1	1
8	315 Front Street	Vic Ouimette	Y	1	1
8	317 Front Street	Vic Ouimette	Y	1	1
9 & 10	301-307 Front Street	John and Tim Teichmiller	Y	2	3
11	527 Oneida Street	Scot and Susan Bassett	Y	1	1
12	***Property contains a public restroom and based on the delineated PCE/TCE plume extents, no further assessment will be completed at this time.***				
13	300 Front Street	David and Susan Jaster	N	1	1
14	***Property does not contains any building/structures, and will not be further assessed.***				
15	***Property contains a building, but based on the delineated PCE/TCE plume extents, no further assessment will be completed at this time.***				
16	***Property contains a building, but based on the delineated PCE/TCE plume extents, no further assessment will be completed at this time.***				

Notes:
1. The above sampling quantities are estimated per monitoring event.
2. Two outdoor air samples will be collected during each monitoring event.

Created By: A.Stehn 2/11/2018
Checked By: T.O'Connell 2/21/2018

Table 2
Vapor Intrusion Assessment Monitoring Schedule
Former Northwood's Laundry (BRRTS #02-44-000517, WISDOT #0656-50-31)
Minocqua, Oneida County, Wisconsin
TRC Project # 298526.0000.0000

Field Day	TRC Property ID	Task	Sample ID
1	8	Start Outdoor Air Sample 1	Outdoor - 1
	4	Start Indoor Air Canister	515-IA
	5	Start Indoor Air Canister	329-IA
	7	Start Indoor Air Canister	321-A
	8	Start Indoor Air Canisters	313-IA, 315-IA, and 317-IA
	9&10	Start Indoor Air Canisters	301-307 IA-C and 301-307 IA-S
2	8	Finish Outdoor Air Sample 1	Outdoor - 1
	13	Start Outdoor Air Sample 2	Outdoor - 2
		Start Indoor Air Canister	300 - IA
	3	Install Sub-slab Port and Sample	405-SS
	11	Start Indoor Air Canister	527-IA
	4	Finish Indoor Air Canister	515-IA
		Install Sub-slab Port and Sample	515-SS
	5	Finish Indoor Air Canister	329-IA
		Install Sub-slab Port and Sample	329-SS
	7	Finish Indoor Air Canister	321-IA
		Install Sub-slab Port and Sample	321-SS
	8	Finish Indoor Air Canisters	313-IA, 315-IA, and 317-IA
		Install Sub-slab Port and Sample	313-SS, 315-SS, and 317-SS
	9&10	Finish Indoor Air Canisters	301-307 IA-C and 301-307 IA-S
		Install Sub-slab Ports and Sample	301-307 SS-1, 301-307 SS-2, and 301-307 SS-3
3	13	Finish Outdoor Air Sample 2	Outdoor - 2
		Finish Indoor Air Canister	300 - IA
		Install Sub-slab Port and Sample	300 - SS
	11	Finish Indoor Air Canister	527 - IA
		Install Sub-slab Port and Sample	527 - SS

Created By: A.Stehn 02/27/2018
Checked By: A.Schroeder 2/27/2018

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

708 Heartland Trail
Suite 3000
Madison, WI 53717
Phone: 608.826.3600

TRC - GIS

PROJECT:

WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:

SITE LOCATION MAP

DRAWN BY:	R. SUEMNICHT
CHECKED BY:	A. STEHN
APPROVED BY:	T. O'CONNELL
DATE:	MARCH 2018
PROJ. NO.:	298526
FILE:	298526-010slm.mxd

FIGURE 1

E:\WI_DOT\2016_242567\298526-010slm.mxd -- Saved By: RSUEMNICHT on 3/9/2018, 14:02:04 PM

LEGEND

- TRC SMALL DIAMETER PIEZOMETER
- TRC SMALL DIAMETER WATER TABLE WELL
- NOVEMBER 2017 PCE ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- APPROXIMATE PARCEL BOUNDARY

WELL ID
PCE
TCE
cis-1,2-DCE
VC

NOVEMBER 2017 SAMPLING RESULTS (µg/L)

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP PROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN- NORTH (US SURVEY FEET).
3. TRC SMALL DIAMETER WELLS AND PIEZOMETERS WERE SAMPLED NOVEMBER 30TH AND DECEMBER 1ST, 2017.
4. PARCEL DATA ACQUIRED FROM WISCONSIN STATE CARTOGRAPHER'S OFFICE. LOCATIONS ARE APPROXIMATE.
5. SAMPLING RESULTS WITH A J QUALIFIER INDICATE AN ESTIMATED CONCENTRATION AT OR ABOVE THE LIMIT OF DETECTION AND BELOW THE LIMIT OF QUANTITATION.

0 100 200 Feet
1 " = 100 '
1:1,200

PROJECT:
WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:
PCE GROUNDWATER ISOCONCENTRATION MAP NOVEMBER 2017

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		**FIGURE 2**
APPROVED BY:	T. O'CONNELL		
DATE:	MARCH 2018		

TRC
708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

FILE NO.: 298526-011.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

Plot Date: 3/9/2018, 14:03:48 PM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
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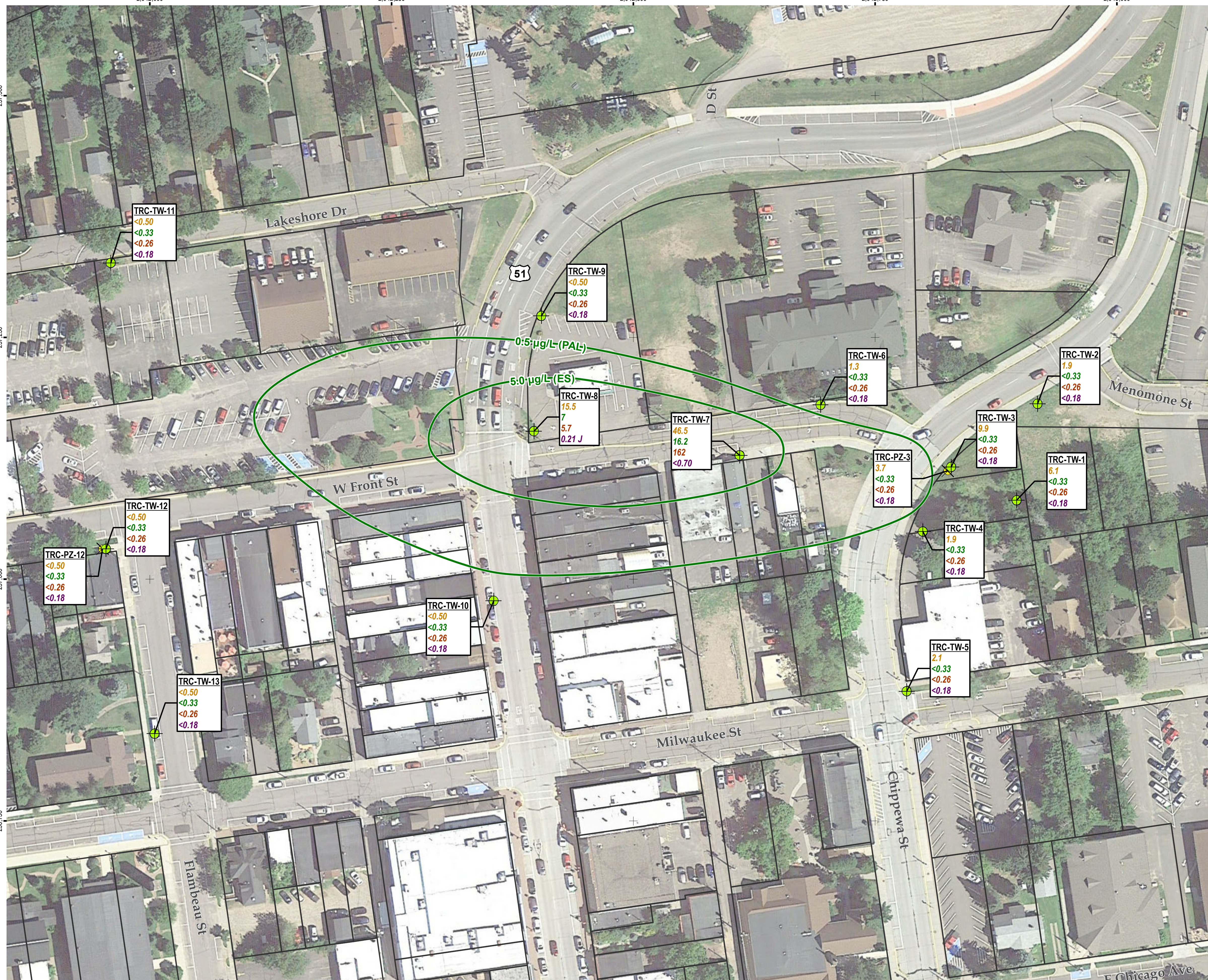

LEGEND

- TRC SMALL DIAMETER PIEZOMETER
- TRC SMALL DIAMETER WATER TABLE WELL
- NOVEMBER 2017 TCE ISOCONCENTRATION CONTOUR
- APPROXIMATE PARCEL BOUNDARY

WELL ID
PCE
TCE
cis-1,2-DCE
VC

NOVEMBER 2017 SAMPLING RESULTS (µg/L)

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP PROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN- NORTH (US SURVEY FEET).
3. TRC SMALL DIAMETER WELLS AND PIEZOMETERS WERE SAMPLED NOVEMBER 30TH AND DECEMBER 1ST, 2017.
4. PARCEL DATA ACQUIRED FROM WISCONSIN STATE CARTOGRAPHER'S OFFICE. LOCATIONS ARE APPROXIMATE.
5. SAMPLING RESULTS WITH A J QUALIFIER INDICATE AN ESTIMATED CONCENTRATION AT OR ABOVE THE LIMIT OF DETECTIN AND BELOW THE LIMIT OF QUANTITATION.

0 100 200 Feet

1 " = 100 '

1:1,200

N

PROJECT:

WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:

TCE GROUNDWATER ISOCONCENTRATION MAP NOVEMBER 2017

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		
APPROVED BY:	T. O'CONNELL		**FIGURE 3**
DATE:	MARCH 2018		

TRC

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Madison, WI 53717
Phone: 608.826.3600
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FILE NO.: 298526-012.mxd

TRC - GIS

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Map Rotation: 0

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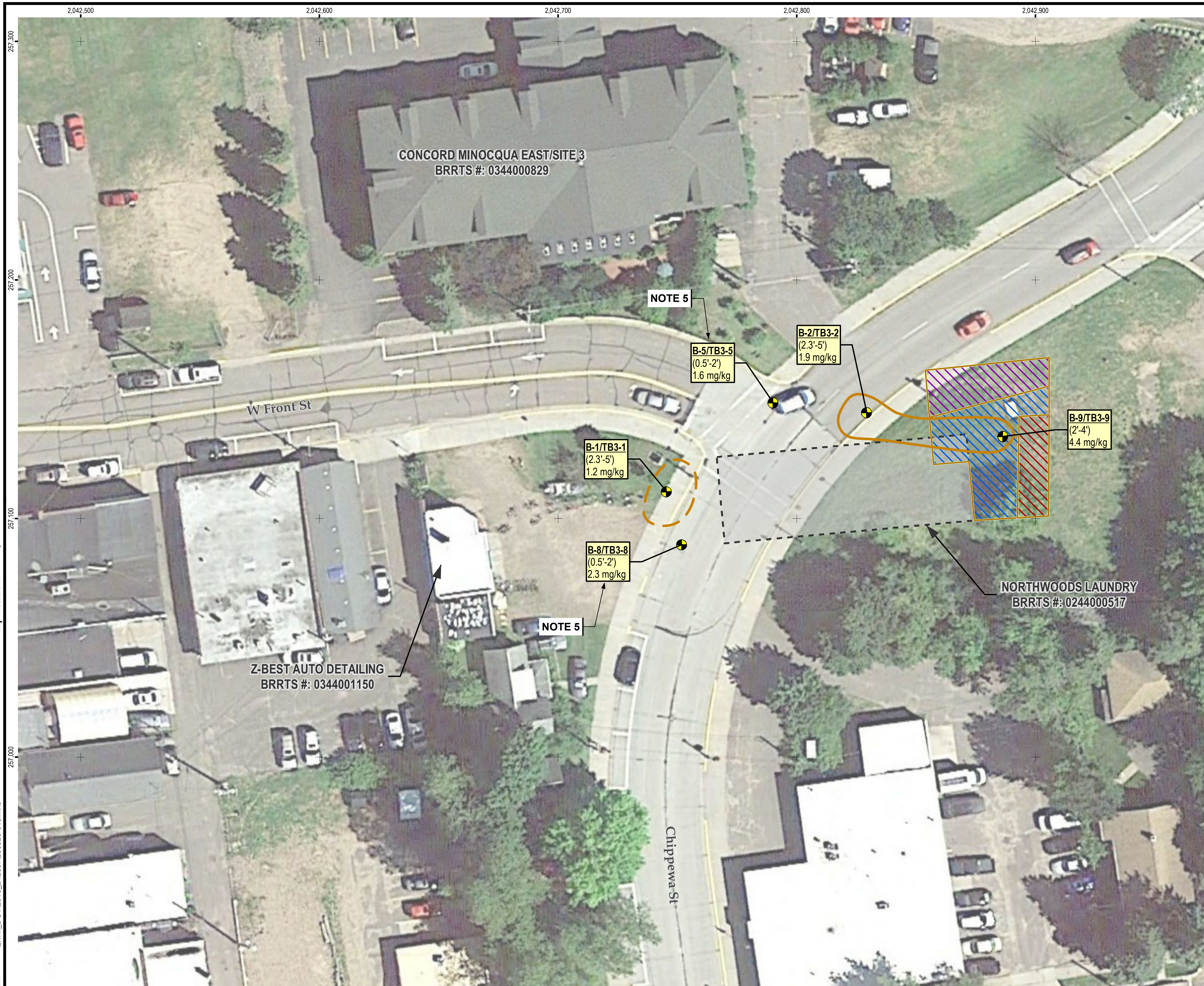

LEGEND

- APPROXIMATE SOIL BORING LOCATION
- NR 720 GROUNDWATER PATHWAY EXCEEDANCE FOR PCE (DASHED WHERE INFERRED)
- 2' DEPTH EXCAVATION
- 4' DEPTH EXCAVATION
- 5' DEPTH EXCAVATION
- APPROXIMATE FORMER NORTHWOODS LAUNDRY BUILDING EXTENT

SAMPLE ID
(DEPTH IN FEET)
PCE CONCENTRATION (mg/kg)

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP PROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN- NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS ARE APPROXIMATE.
4. SOIL DATA SHOWN WAS COLLECTED DURING AN INVESTIGATION COMPLETED IN 1994. ONLY SAMPLE RESULTS OUT OF THE LIMITS OF THE REMEDIAL EXCAVATIONS WITH NR 720 EXCEEDANCES ARE SHOWN. THE NOTED RESULTS ARE ESTIMATED BASED ON HISTORICAL SITE INFORMATION.
5. BASED ON THE RECONSTRUCTION OF USH 51 LIKELY REMOVING SHALLOW IMPACTED SOIL, SOIL DATA FROM BORING B-5/TB3-5 AND B-8/TB3-8 WAS NOT USED FOR DELINEATION OF THE NR 720 GROUNDWATER PATHWAY EXCEEDANCE FOR PCE EXTENTS.

N

0 40 80 Feet

1 " = 40 '
1:480

PROJECT:
WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:
PCE IMPACTED SOIL MAP

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		
APPROVED BY:	T. O'CONNELL		**FIGURE 4**
DATE:	MARCH 2018		

TRC

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FILE NO.: 298526-015.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

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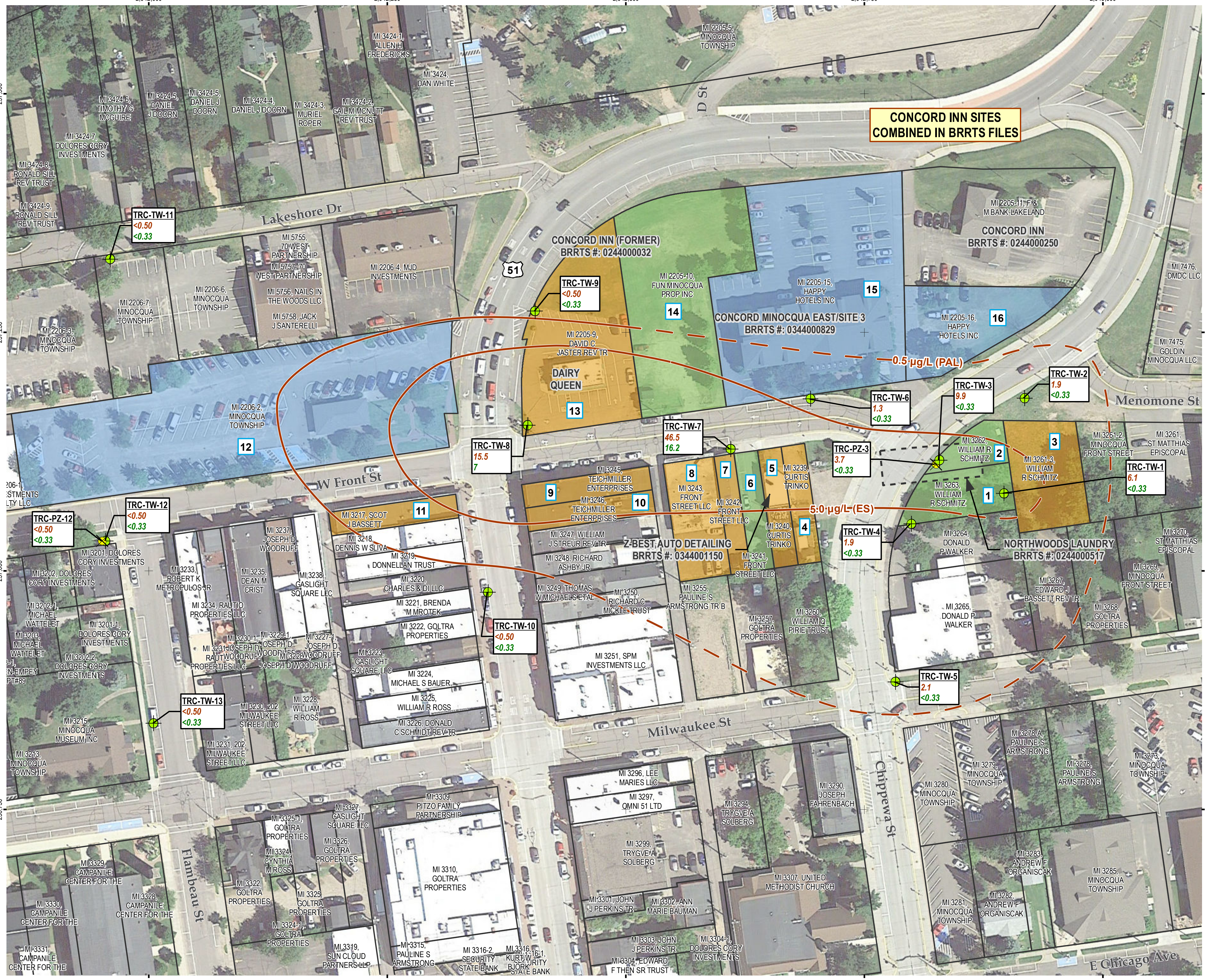

LEGEND

- TRC SMALL DIAMETER PIEZOMETER
- TRC SMALL DIAMETER WATER TABLE WELL
- NOVEMBER 2017 PCE ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- VAPOR SAMPLING IS NOT RECOMMENDED AS NO BUILDINGS ARE PRESENT
- PARCEL WAS INVESTIGATED AND VAPOR SAMPLING IS RECOMMENDED
- VAPOR SAMPLING IS NOT RECOMMENDED BASED ON EXTENTS OF CONTAMINATION
- APPROXIMATE FORMER NORTHWOODS LAUNDRY BUILDING EXTENT
- WELL ID / *PCE* / *TCE* — NOVEMBER 2017 SAMPLING RESULTS (µg/L)
- 1 — TRC PROPERTY ID

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP PROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN- NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS ARE APPROXIMATE.
4. TRC SMALL DIAMETER WELLS AND PIEZOMETERS WERE SAMPLED NOVEMBER 30TH AND DECEMBER 1ST, 2017.

PROJECT:
WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:
SITE OVERVIEW MAP -
VAPOR INTRUSION EVALUATION

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		
APPROVED BY:	T. O'CONNELL	**FIGURE 5**	
DATE:	MARCH 2018		

TRC

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FILE NO.: 298526-013.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

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Path: E:\WI_DOT\2016_242567\298526-013.mxd

LEGEND

- 1 TRC PROPERTY ID
- PROPOSED SUB-SLAB SAMPLE
- APPROXIMATE BUILDING EXTENT
- APPROXIMATE FORMER NORTHWOODS LAUNDRY BUILDING EXTENT
- APPROXIMATE PARCEL BOUNDARY

NOTES

1. BASEMAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP ROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN-NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS AND SIZES ARE APPROXIMATE.
4. BUILDING CONTAINS A SLAB CONSTRUCTED ON GRADE, NO LOWER LEVEL PRESENT.
5. NO INDOOR AIR SAMPLE IS PROPOSED BASED ON THE BUILDING CONDITION.

0 20 40 Feet

1 " = 20 '

1:240

N

PROJECT:

WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:

PROPERTY LAYOUT - PROPERTY IDs 1 THROUGH 3

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		**FIGURE 6**
APPROVED BY:	T. O'CONNELL		
DATE:	MARCH 2018		

TRC

708 Heartland Trail, Suite 3000
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FILE NO.: 298526-014mb.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

Plot Date: 3/9/2018, 14:22:10 PM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
Path: E:\WI_DOT\2016_242567\298526-014mb.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

Plot Date: 3/9/2018, 14:22:10 PM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
Path: E:\WI_DOT\2016_242567\298526-014mb.mxd

LEGEND

- 1 TRC PROPERTY ID
- PROPOSED INDOOR AIR SAMPLE
- PROPOSED OUTDOOR SAMPLE
- PROPOSED SUB-SLAB SAMPLE
- APPROXIMATE LOCATION OF SUMP CROCK
- APPROXIMATE LOCATION OF STAIRS
- APPROXIMATE BUILDING EXTENT
- APPROXIMATE BUILDING EXTENT WITH NO ACCESS
- APPROXIMATE LOWER LEVEL CONCRETE FLOOR
- APPROXIMATE PARCEL BOUNDARY

NOTES

1. BASEMAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP ROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN-NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS AND SIZES ARE APPROXIMATE.
4. BUILDING CONTAINS A SLAB CONSTRUCTED ON GRADE, NO LOWER LEVEL PRESENT.

PROJECT:
WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:
PROPERTY LAYOUT - PROPERTY IDs 4 THROUGH 8

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN	**FIGURE 7**	
APPROVED BY:	T. O'CONNELL		
DATE:	MARCH 2018		

TRC

708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
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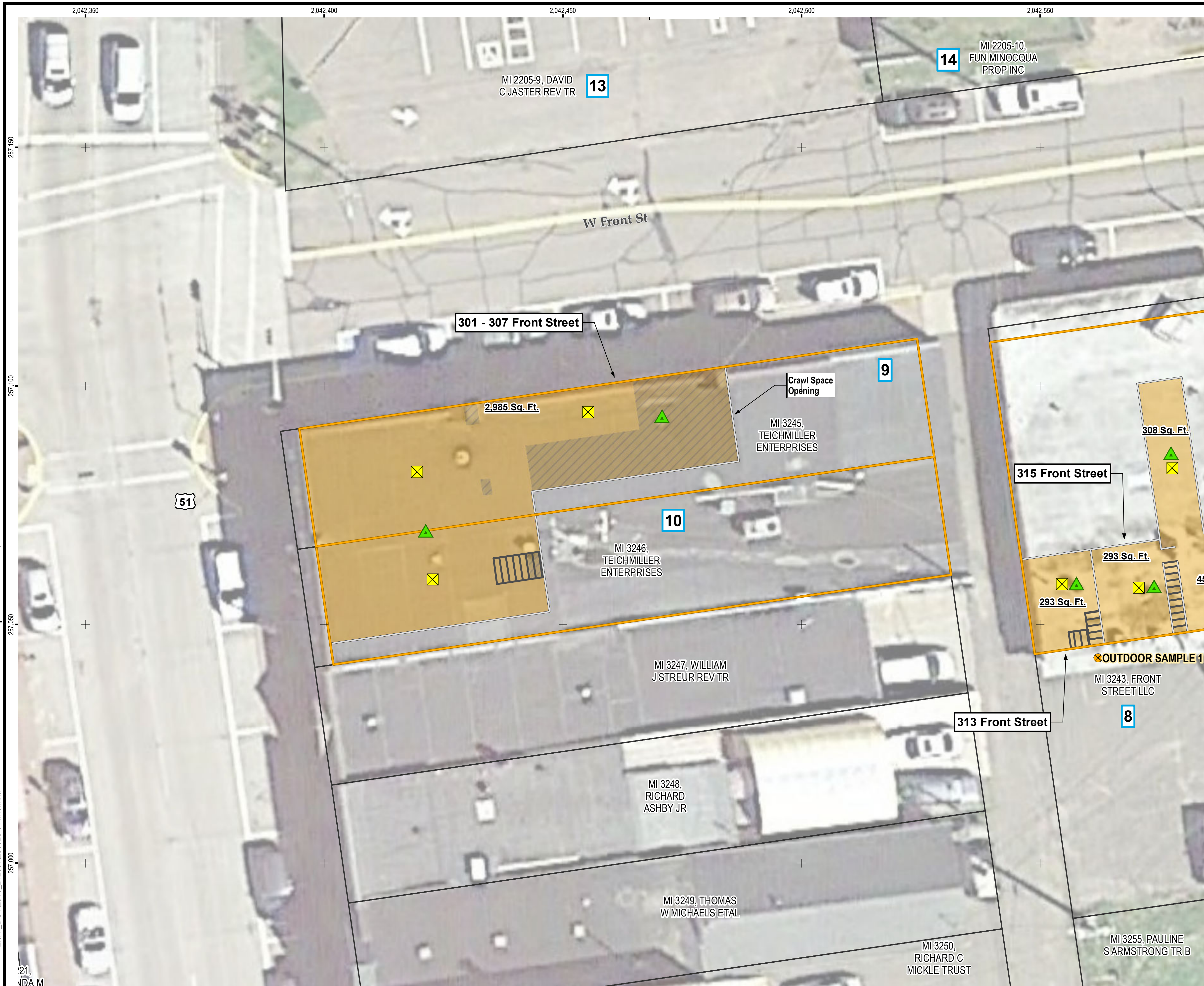
FILE NO.: 298526-014mb.mxd



LEGEND

- 1 TRC PROPERTY ID
- PROPOSED INDOOR AIR SAMPLE
- PROPOSED OUTDOOR SAMPLE
- PROPOSED SUB-SLAB SAMPLE
- APPROXIMATE LOCATION OF STAIRS
- APPROXIMATE BUILDING EXTENT
- APPROXIMATE LOWER LEVEL DIRT FLOOR
- APPROXIMATE LOWER LEVEL CONCRETE FLOOR
- APPROXIMATE PARCEL BOUNDARY

NOTES

1. BASEMAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP ROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN-NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS AND SIZES ARE APPROXIMATE.

0 20 40 Feet

1 " = 20 '

1:240

N

PROJECT:

WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:

PROPERTY LAYOUT - PROPERTY IDs 9 AND 10

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		
APPROVED BY:	T. O'CONNELL		**FIGURE 8**
DATE:	MARCH 2018		

TRC

708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

FILE NO.: 298526-014mb.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

Plot Date: 3/9/2018, 14:22:10 PM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
Path: E:\WI_DOT\2016_242567\298526-014mb.mxd

LEGEND

- 1 TRC PROPERTY ID
- PROPOSED INDOOR AIR SAMPLE
- PROPOSED SUB-SLAB SAMPLE
- APPROXIMATE LOCATION OF SUMP CROCK
- APPROXIMATE LOCATION OF STAIRS
- APPROXIMATE BUILDING EXTENT
- APPROXIMATE BUILDING EXTENT WITH NO ACCESS
- APPROXIMATE LOWER LEVEL CONCRETE FLOOR
- APPROXIMATE PARCEL BOUNDARY

NOTES

1. BASEMAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP ROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN-NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS AND SIZES ARE APPROXIMATE.
4. BUILDING CONTAINS A SLAB CONSTRUCTED ON GRADE, NO LOWER LEVEL PRESENT.
5. THE NOTED SQUARE FOOTAGE DOES NOT INCLUDE THE PAVILION LIMITS.

0 20 40 Feet
1 " = 20 '
1:240

N

PROJECT:
WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:
PROPERTY LAYOUT - PROPERTY IDs 11 AND 12

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN	**FIGURE 9**	
APPROVED BY:	T. O'CONNELL		
DATE:	MARCH 2018		

TRC

708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

FILE NO.: 298526-014mb.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

Plot Date: 3/9/2018, 14:22:10 PM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
Path: E:\WI_DOT\2016_242567\298526-014mb.mxd

LEGEND

- 1 TRC PROPERTY ID
- PROPOSED INDOOR AIR SAMPLE
- PROPOSED OUTDOOR SAMPLE
- PROPOSED SUB-SLAB SAMPLE
- APPROXIMATE BUILDING EXTENT
- APPROXIMATE PARCEL BOUNDARY

NOTES

1. BASEMAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, JULY 2015.
2. MAP ROJECTION AND GRID COORDINATES ARE NAD83 STATE PLANE WISCONSIN-NORTH (US SURVEY FEET).
3. ALL MAP FEATURE LOCATIONS AND SIZES ARE APPROXIMATE.
4. BUILDING CONTAINS A SLAB CONSTRUCTED ON GRADE, NO LOWER LEVEL PRESENT.

0 20 40 Feet
1 " = 20 '
1:240

N

PROJECT:
WISDOT ID# 0656-50-31
FORMER NORTHWOODS LAUNDRY
MINOCQUA, ONEIDA COUNTY, WISCONSIN

TITLE:
PROPERTY LAYOUT - PROPERTY ID 13

DRAWN BY:	R. SUEMNICHT	PROJ NO.:	298526
CHECKED BY:	A. STEHN		
APPROVED BY:	T. O'CONNELL	**FIGURE 10**	
DATE:	MARCH 2018		

TRC
708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

FILE NO.: 298526-014mb.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet (Foot US)
Map Rotation: 0

Plot Date: 3/9/2018, 14:22:10 PM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
Path: E:\WI_DOT\2016_242567\298526-014mb.mxd

Appendix A
Standard Operating Procedures

Title: **Soil Vapor Point Installation and Active Vapor Sampling**	Procedure Number: **ECR 015**
	Revision Number: **0**
	Effective Date: **July 2016**

Authorization Signatures			
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Stacy Metz	7/28/16	Elizabeth Denly	7/28/16

TABLE OF CONTENTS

TABLE

LIST OF ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in active soil vapor sampling activities. This SOP details equipment and sampling procedures for low-flow sampling from temporary or permanent soil vapor points as well as the procedures for installation of these soil vapor points. The focus of this SOP is on evacuated canister sampling; other sampling containers such as evacuated bottles or Tedlar® sampling bags may be appropriate but are not covered in this SOP. Various regulatory agencies and project-specific work plans may have different specific requirements (e.g., equipment/instrument, flow rate) which may supersede this SOP, depending on the program.

The objective of soil vapor sampling is to obtain a representative sample of vapor from the vadose zone immediately below the floor of a building or other area of concern. Areas of concern may be within, above, or adjacent to a soil or groundwater contaminant source area.

1.2 Summary of Method

This method has been developed to describe how to collect representative samples of soil vapor from the vadose zone. Temporary or permanent points can be installed depending on project objectives. Installation of several types of permanent and temporary points are described herein. Sample collection methods include verification that a representative soil vapor sample has been collected and that the sample was not compromised by leakage of sampling components or the sampling point itself. Field verification of sample integrity may include a shut-in leak test, quantitative tracer testing, and/or semi-quantitative tracer testing, depending on project objectives and regulatory requirements. Leak detection is an integral part of soil vapor sampling and is explained in detail in Attachment D. Photographs referenced within this SOP are included in Attachment A. Soil vapor point diagrams referenced within this SOP are included in Attachment B.

1.3 Equipment

The following equipment list is meant to be a guide of the typical equipment that can be used to install a soil vapor point and collect a soil vapor sample, unless project needs dictate a different set of equipment. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Applicable Safety Data Sheets (SDSs)
- Non-powdered, disposable gloves
- Field logbook and/or appropriate field forms
- Digital camera
- Calculator

Installation of Permanent Points via Flush-mount Well Cover Method (Section 2.1.2):

- Soil vapor probe materials (stainless-steel or brass):
  - $^{1}/_{4}$-inch diameter ball valve;
  - $^{1}/_{4}$-inch male thread by $^{1}/_{8}$-inch diameter hose barb fitting;
  - $^{1}/_{4}$-inch diameter nipple (length dependent upon slab thickness)
- Alconox® or equivalent
- Distilled water
- Teflon® tape
- Wrenches
- Appropriate field screening device(s), e.g., photoionization detector (PID), flame ionization detector (FID), and/or landfill gas meter (optional)
- If concrete coring is required*:
  - Concrete coring machine with diameter approximately 2-inches larger than well cover
  - Concrete core barrel
  - Extension cord(s)
  - Heavy-duty vacuum (e.g., Shop-Vac®)
  - Generator, if needed
- Source of clean water and buckets or hose
- Paper towels
- Aluminum flush-mount well cover, typically 4-inch diameter
- Reciprocating saw with metal cutting blades
- Hydraulic cement or equivalent
- Grout/Portland cement
- Trowel and other tools to mix and place cement

*****Common to have driller or qualified subcontractor perform the coring; see Project Manager for instructions.

Installation of Permanent Points via Stainless-steel Probe Method (Section 2.1.3):

- Soil vapor probe materials:
  - $^{1}/_{4}$-inch outer diameter (OD), gas chromatography grade 316 stainless-steel tubing
  - $^{1}/_{4}$-inch stainless-steel coupling with a female National Pipe Thread (NPT) fitting (top) with ¼-inch OD tubing compression fitting (bottom)
  - $^{1}/_{4}$-inch male NPT plug
  - Stainless-steel washer, optional ($^{3}/_{8}$-inch inner diameter [ID], OD less than 1-inch and greater than $^{1}/_{2}$-inch)
- Alconox® or equivalent
- Distilled water
- $^{7}/_{16}$-inch socket
- Wrenches
- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- Rotary hammer drill equipped with 1-inch drill bit
- Rotary hammer drill equipped with $^{3}/_{8}$-inch or $^{1}/_{2}$-inch drill bit
- Extension cord(s)
- Paper towels

- Heavy-duty vacuum (e.g., Shop-Vac®), optional
- Stainless-steel tubing cutter
- Granular bentonite or bentonite/cement
- Flathead screwdriver
- Hydraulic cement or equivalent
- 1-inch diameter sink hole cover

Installation of Temporary Sub-slab Soil Vapor Points (Section 2.1.4):

- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- Rotary hammer drill equipped with 1-inch drill bit
- Rotary hammer drill equipped with $^{3}/_{8}$-inch or $^{1}/_{2}$-inch drill bit
- Extension cord(s)
- Generator, if needed
- Paper towels
- Distilled water
- Teflon® or Teflon®-lined polyethylene tubing
- Scissors or tubing cutter
- Granular bentonite
- Container for preparing bentonite
- Materials to close sample port during equilibration, one option outlined below:
  - Polycarbonate stopcock (such as Cole Parmer EW-30600-01)
  - $^{1}/_{4}$-inch barbed fitting (such as Cole Parmer EW-45503-19)
  - $^{1}/_{8}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
  - $^{1}/_{4}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)
- Materials to create appropriate surface seal/patch on abandoned borehole
  - Pre-mixed, non-shrinking grout (quick-dry)
  - Container for preparing grout
  - Concrete tools (trowel and $^{1}/_{4}$-inch diameter rod)

Installation of Permanent Deep Soil Vapor Points (Section 2.1.5):

- Soil vapor probe materials:
  - Stainless-steel mesh vapor point with ¼-inch barb fitting or with a ¼-inch compression fitting
  - $^{1}/_{4}$-inch OD inert tubing (such as Teflon® or Teflon®-lined polyethylene)
- Alconox® or equivalent
- Distilled water
- Teflon® tape, if compression fitting is used
- Wrenches, if compression fitting is used
- Scissors or tubing cutter
- Zip ties, if barbed fitting is used
- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- If concrete coring is required*:
  - Concrete coring machine
  - Concrete core barrel with diameter approximately 2-inches greater than well cover
  - Extension cord(s)

- Heavy-duty vacuum (e.g., Shop-Vac®)
  - Generator, if needed
- Hand auger
- Direct-push drilling equipment equipped with 3-inch rods, recommended**
- Measuring tape
- Appropriate materials to decontaminate drilling equipment between locations
- Source of water for decontaminating
- Paper towels
- Filter pack of glass beads (60-100 mesh) or fine sand (20-40 mesh), or other appropriately sized inert material based on stainless-steel probe manufacturer recommendations
- Medium sand (optional)
- Granular bentonite
- Grout/Portland cement, or equivalent
- Shovel
- Aluminum flush-mount well cover, typically 4- to 8-inch diameter
- Redi-Mix concrete
- Sand or gravel for drainage layer
- Materials to close sample port, one option outlined below:
  - Polycarbonate stopcock (such as Cole Parmer EW-30600-01)
  - 1/4-inch barbed fitting (such as Cole Parmer EW-45503-19)
  - 1/8-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
  - 1/4-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)

*****Common to have driller or qualified subcontractor perform the coring; see Project Manager for instructions.

******In certain geologic conditions (e.g., hole stays open to target depth), deep soil vapor points may be installed with a hand auger. However it is typically recommended that a qualified driller install the borehole with direct push drilling equipment. Direct push methods minimize the sub-surface disturbance, reducing the likelihood of leaks and short-circuiting during sample collection.

Installation of Temporary Deep Soil Vapor Points (Section 2.1.6):

- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- Hand auger, if required
- Direct-push drilling equipment, recommended*
- Appropriate materials to decontaminate drilling equipment between locations
- Source of water for decontaminating
- Teflon® or Teflon®-lined polyethylene tubing
- Scissors or tubing cutter
- Sand
- Measuring tape
- Granular bentonite
- Distilled water
- Materials to close sample port during equilibration, one option outlined below:
  - Polycarbonate stopcock (such as Cole Parmer EW-30600-01)
  - 1/4-inch barbed fitting (such as Cole Parmer EW-45503-19)

  - $^1/_8$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
  - $^1/_4$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)
- Materials to create appropriate surface seal/patch on abandoned borehole
  - Pre-mixed, non-shrinking grout (quick-dry)
  - Container for preparing grout
  - Concrete tools (trowel and $^1/_4$-inch diameter rod)

*****In certain geologic conditions (e.g., hole stays open to target depth), deep soil vapor points may be installed with a hand auger. However, it is typically recommended that a qualified driller install the borehole with direct push drilling equipment. Direct push methods minimize the sub-surface disturbance, reducing the likelihood of leaks and short-circuiting during sample collection.

Sample Collection:

- Pre-cleaned, evacuated, passivated stainless-steel canister (hereafter - sampling canister), at least one extra for every 20 samples recommended in case of leakage
- Flow controller(s) with flow rate pre-set by laboratory to meet project objectives, typically between 100 and 200 milliliters per minute (mL/min)
- Digital vacuum gauge, optional
- $^1/_4$-inch diameter Teflon®, Teflon®-lined, Nylaflow® and/or other inert tubing (optional)
- Applicable components to form sample collection train; components will vary depending on sample point construction and project requirements, but may include:
  - Stopcock (such as Cole Parmer EW-30600-01, or similar)
  - In-line moisture filter (e.g., Millipore #SLGVS25US, or equivalent)
  - ¼-inch barbed fittings (such as Cole Parmer EW-45503-19)
  - Flexible tubing (do NOT use silicone)
    - $^1/_8$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
    - $^1/_4$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)
  - $^1/_4$-inch OD stainless-steel tee
  - $^1/_4$-inch OD stainless-steel port connectors
  - $^1/_4$-inch stainless-steel nuts and ferrules
  - $^1/_4$-inch OD stainless-steel ball valve
  - $^1/_4$-inch O-rings
  - $^1/_4$-inch OD, gas chromatography grade 316 stainless-steel male/male coupling
- Teflon® tape
- Zip ties
- Scissors or tubing cutter
- Appropriate tools to open sample collection points (project-specific)
  - Sockets ($^7/_{16}$-inch, $^1/_2$-inch, and/or $^3/_8$-inch) and driver;
  - Wrenches;
  - Allen wrench, and/or
  - Flat-head screwdriver
- Granular bentonite
- Distilled water
- 50 mL graduated syringe or pump to purge sample port (inert gas detector for tracer gas testing may also serve this purpose)

- Flexible tubing (material does not matter) to form connection between syringe or pump and sample point
- Air flow rate meter (e.g., DryCal® DC-Lite), optional (see Section 2.2.3)
- Watch or timer (capable of monitoring time to the nearest second)
- PID, FID, landfill gas meter and/or other project-specific field screening devices (optional)
- Materials required for completing project-specific leak-testing; equipment lists for various leak-test options are provided in Attachment D

1.4 Definitions

Active Soil Vapor Sampling — A volume of soil vapor or soil gas is pumped out of the vadose zone into a sample collection device for analysis.

Batch Certification — A laboratory will clean several sampling canisters at once. One canister from that group of canisters, i.e., the batch, is used to certify that all of the canisters in that batch are clean.

Building Stack Effects — The natural phenomenon of how air moves in and out of a building primarily due to pressure and temperature differences. Buildings are not totally sealed – they leak. Since air density decreases with increasing warmth, in cool or cold weather, warm interior air tends to leak from the upper portion of the building and cooler air tends to infiltrate the bottom of the building. In air conditioned buildings, this phenomenon is reversed causing warmer exterior air to infiltrate the upper portion of the building and cooler interior air to leak from the bottom portion of the building. These building stack effects can cause increased soil vapor flux around the building perimeter. This increased flux tends to be greater for large buildings because the total building area is relatively high in comparison to the building perimeter.

Individual Certification — A laboratory will clean several sampling canisters at once. Each canister from the batch is certified clean.

Passive Soil Gas Sampling — A sampler containing a sorbent material with an affinity for the target analytes is placed in the ground for a period of time, so that contaminant vapors can be adsorbed over time using the ambient flow of soil gas.

Purge Volume — The total volume, typically measured in milliliters (mL), of air/gas/vapor contained within the sample collection system and sampling point (e.g., tubing, void space within the boring, and/or void space below the slab).

Selected Ion Monitoring (SIM)	Analysis using gas chromatography/mass spectrometry (typically EPA TO-15), whereby only those masses of the known contaminants of interest in the known elution time period are scanned instead of scanning a wide range of masses (35-500 atomic mass units [amu]) every second. SIM analysis allows for greater specificity and much greater sensitivity than scanning in the full-scan mode, since the mass spectrometer is set to dwell for longer period times on a restricted number of masses. SIM analysis is most common for indoor air sample analysis, and is typically not required for soil vapor sample analysis.
Vadose Zone	The zone of soil above the water table and below the ground surface in which the pores between soil grains are at least partially filled with vapor.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous materials and TRC personnel must appropriately handle and store them at all times. SDSs must accompany reagents or compressed gases.

The rotary hammer drill bits can become extremely hot during drilling. The proper gloves should be worn during drilling to prevent serious burns.

Drilling equipment including the concrete coring machine, the rotary hammer drill, and the Geoprobe® may generate dust and noise; therefore, a dust mask and/or hearing protection should be worn during use, as conditions warrant.

The appropriate cut-/puncture-resistant gloves should be used for this task. Refer to the Glove Section Guidelines in TRC's Hand Protection Policy.

1.6 Cautions and Potential Problems

(a) Compression fittings, where applicable, as opposed to tube-in-tube connections are typically recommended for air sampling. However, over tightening compression fittings may cause damage/deformation, resulting in leakage during subsequent use. Any leaks of ambient air through fittings between pieces of the sampling train will dilute the sample. The integrity of connections within the sampling train should be verified with a shut-in leak test, or equivalent.

(b) Leaks within the sample collection apparatus may result in leakage of ambient air, and a low sample bias. Leak testing must be performed to verify that a representative sample is collected. Note that certain laboratories, particularly those which specialize in ambient air, indoor air, or stack-testing rather than soil vapor testing, may not maintain their equipment to the standard required to pass a shut-in leak test. Typical leakage rates during shut-in leak tests should be less than 5-percent. If higher leakage rates are observed for the canister-flow controller connection, an alternative laboratory should be considered. If needed, experienced personnel on the TRC Vapor Intrusion CORE Team can provide a recommendation for a laboratory which maintains sampling canisters and flow controllers to the necessary standard for soil vapor sampling.

(c) Water vapor in the sample may compromise the laboratory instrumentation and prevent sample analysis. Measures should be taken to prevent moisture from entering the sampling canister. Soil vapor points should not be in contact with the water table. In many environments, soil vapors may be high in moisture, and condensate may form with temperature fluctuations (particularly at exterior locations or at inactive sites where heating/cooling systems are not operational). Sample collection lines should be monitored for visible moisture. Typically, an in-line moisture filter should be used during sample collection to prevent unacceptable levels of moisture from compromising the sample. If water is observed, the possible presence of water in the sample should be noted on the chain-of-custody. If the laboratory knows that water may be present, measures can be taken to prevent the water from entering the instrumentation.

(d) The inert gas detector may yield a false positive response in high moisture conditions. Under these conditions, it is recommended that an alternative semi-quantitative tracer, such as 1,1-difluoroethane (commercially available as electronic dusting spray), be used in place of inert gas tracer testing.

(e) Although sampling equipment (e.g., flow controllers and sampling canisters) is typically not damaged by extreme temperatures, the functionality of sampling equipment may be temporarily affected by extreme temperatures. Protect the flow controller and sampling canister from extreme temperatures (<20°F) immediately prior to and during sample collection.

(f) The sampler should be cognizant of the purge volume of the sample tubing and should remove at least one purge volume prior to inert gas testing and three purge volumes prior to sample collection. Purging a point is similar to purging a groundwater monitoring well in that under purging can create a low bias. Do not purge more than five volumes of the tubing and/or sampling point. Significant over purging can cause low bias and sample representativeness issues, as soil vapor that has accumulated adjacent to the sampling point could be evacuated and vapor from beyond the target sampling location would then migrate to fill the low-pressure zone. If a PID, FID, landfill gas meter or other field screening device is used prior to sample collection, caution should be used regarding the number of purge volumes being removed.

(g) Many common construction materials, particularly plastics have the potential to absorb volatile organic compounds (VOCs). Sampling points should be constructed using stainless-steel, brass, Teflon®, Teflon®-lined, Nylaflow® and/or other materials that have been demonstrated to be inert in soil vapor/air sampling applications.

(h) Teflon®, Teflon®-lined, Nylaflow®, and/or other tubing that has been shown to be inert should be used to the extent possible in the sample collection train. Flexible tubing has the potential to absorb small amounts of VOCs. Therefore the use of flexible tubing should be minimized to the extent reasonable. However short sections of flexible tubing are often required to make air-tight connections within the sample collection apparatus. Flexible silicone tubing should not be used for these connections. Depending on the manufacturing process, certain batches of silicone tubing may release siloxane vapors. These vapors may cause matrix interference and compromise sample reporting limits. Short sections of Tygon® tubing are recommended as opposed to silicon tubing where flexible tubing is necessary. Due to the potential for VOC absorption/desorption, flexible tubing within the sample collection train should be replaced prior to each sampling event.

(i) Many common materials can contain VOCs. Eliminate to the extent possible the use of VOC-containing materials (e.g., perfumes, glues, modeling clay, etc.) during sample point installation and sample collection. If possible, fuel your field vehicle prior to loading field equipment. Make sure hands are washed thoroughly after fueling a vehicle, and prior to handling sampling equipment. Note even sealants, glues, clay, etc. which are labeled "VOC-free" may contain VOCs at parts per billion levels, i.e., the anticipated sensitivity of the sample analysis. These materials also may contain other chemicals which affect analytical instrumentation, even if they are not target chemical (e.g., siloxanes). "Party" helium contains measurable concentrations of several VOCs and should not be used in place of laboratory-grade helium for inert gas tracer testing.

(j) If collecting indoor air at the same locations and at the same time as sub-slab vapor samples, purging should be performed into a Tedlar® bag instead of into ambient air to avoid cross-contamination.

(k) Low permeability soils can cause short-circuiting of soil vapor samples such that ambient air is pulled down through preferential pathways in the soil and collected in place of soil vapor.

(l) In low permeability soils exhibiting high moisture content, active soil vapor sampling methods have the potential to underestimate concentrations of constituents of interest, particularly if impacts are confined to a small area.

(m) If the sampling canister vacuum fails to drop, this may be the result of low permeability soils, cold weather, or other equipment-related issues, which may require troubleshooting. If the problem cannot be resolved, contact the Project Manager to determine how to proceed, as the sampling canister is not filling properly and inadequate sample volume will lead to elevated reporting limits and potential issues with the representativeness of the sample.

(n) Note that the final target vacuum may vary depending on the project and regulatory requirements. Verify appropriate requirements prior to collecting samples. Some projects require that there be some residual vacuum remaining in the canister (typically 2-6 inches mercury [in. Hg]). A field vacuum reading similar to the laboratory receipt vacuum provides a check of the integrity of the canister and demonstrates that no leaks occurred during shipment to the laboratory. Other guidance recommends letting the canister fill completely (e.g., final vacuum of 0 in. Hg); filling the canister to zero eliminates the pressure gradient between the canister and ambient air during sample shipment.

(o) Where constituents of interest exhibit moderate Henry's Law Coefficients (on the order of 10^{-5} atmospheres-meter^3/mole), a short sample period may result in false negatives or low biases potentially associated with the low exchange of air during active sampling. Examples of potential compounds of interest with moderate Henry's Law Coefficients include but are not limited to: Acetonitrile, 4,4'-DDT, dieldrin, and 1,4-dioxane.

(p) Caution should be used when collecting soil vapor at exterior soil vapor sampling locations.

- Depth of Exterior Soil Vapor Points: Typically sampling points that are less than 5 feet below ground surface (ft. bgs) are not recommended. Risk, estimated using shallow exterior soil vapor points, is likely to be underestimated due to leakage of ambient air, particularly adjacent to a building, where the air exchange rate in the soil vapor may be influenced by building stack effects due to heating/cooling systems.
- Moisture: Significant recharge events (e.g., rainfall or snow melt) can temporarily "wash" the vadose zone. Soil vapor sampling at exterior locations should be delayed for at least 48-hours after a significant recharge event. Significant recharge events by definition vary from state to state. If available, check applicable guidance to confirm definition of significant recharge.

(q) In certain situations, it may be more appropriate and cost effective to perform a screening level assessment using an alternative method to reduce or eliminate the need for active soil vapor sampling. For instance:

- Under some regulatory programs, it may be possible to use field screening (e.g., PID, FID) to eliminate the collection of canister samples.
- Passive soil gas sampling modules may be effective in overcoming many limitations to active soil vapor sampling such as low permeability soils, high moisture soils, constituents of interest with moderate Henry's Law Coefficients, and/or the high costs associated with large investigation areas. In certain situations, passive soil gas sampling may be used to eliminate or greatly reduce the need for more costly active soil vapor sampling.

(r) If using a generator during sample point installation, operate the unit away from the sampling area and be sure that the exhaust of the generator is not directed towards the sample or any of the field team members.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Always review the project-specific work plan and/or scope of work for any site-specific sampling procedures. The following sections detail the methods available for installing soil vapor sampling points and collecting active soil vapor samples.

2.1 Installation of Soil Vapor Sampling Points

This section describes several ways to install soil vapor sampling points. The methods described herein are not exhaustive. Other methods for sample point installation may be appropriate depending on regulatory requirements and project objectives. In general soil vapor sampling points must be constructed of inert materials which neither absorb nor desorb VOCs, e.g., stainless-steel, brass, Teflon®, Teflon®-lined, and/or Nylaflow® materials. Additionally soil vapor sampling points must be constructed in a manner that ensures the soil vapor sample is collected from the target sample location and sealed to prevent ambient air leakage.

2.1.1 Pre-installation Activities

Pre-installation activities may include, but are not limited to, the following:

- Premark sampling locations and contact the appropriate entity to locate underground utilities in the area. Confirm sampling locations with the site owner.
- Where soil vapor points are to be installed through concrete or similar, screen cracks, gaps and other annular spaces in the surrounding area with a PID that is approved by the local regulators or is otherwise appropriate for the application. For example, the RAE System ppbRAE model, which is sensitive to 1 part per billion volume (ppbv) is approved in some states and is recommended where allowed.
- Check the depth to water in nearby wells to determine if the slab may be in contact with the water table (especially if in the basement), or for deep points, to help ensure that the sampling point is installed above the water table and capillary fringe.

2.1.2 Installation of a Permanent Sub-slab Vapor Point – Flush-Mount Well Cover Method

This subsection describes the procedure for installing a permanent sub-slab vapor point using the Flush-mount Well Cover Method. Using the Flush-mount Well Cover Method, the sampling point is protected by a flush-mount well cover or small manhole cover. This installation method is recommended in commercial and industrial settings, particularly in areas of high and/or heavy traffic. See Figure B-1 in Attachment B for a cross-sectional diagram of a point installed using the Flush-mount Well Cover Method.

If the slab is thin (e.g., one-inch thick), caution should be used because the probe and flush-mount well cover skirt will need to be cut very short and should not extend more than one or two inches deeper than the base of the slab.

Construction: Permanent Flush-Mount Well Cover Sampling Point

(a) Components:

- $^{1}/_{4}$-inch diameter ball valve;
- $^{1}/_{4}$-inch male thread by $^{1}/_{8}$-inch diameter hose barb fitting; and,
- $^{1}/_{4}$-inch diameter nipple (length dependent upon slab thickness).

(b) Decontaminate any cutting oils from the components using Alconox® or equivalent, and rinse with distilled water.

(c) Attach Teflon® tape to all threads that will be attached to other components.

(d) Attach the hose barb fitting to the ball valve, and use a wrench to tighten securely. Ensure that the ball valve lever is up, toward the barb fitting, when open so that the valve can be opened and closed after installation.

(e) Attach the nipple to the base of the ball valve, and use a wrench to tighten securely.

Installation: Permanent Flush-Mount Well Cover Sampling Point

(a) Select drilling location. Advance core barrel through the concrete slab and remove the core. Recover the concrete coring water with a heavy-duty vacuum. The concrete core should be large enough to set, grout and seal the flush-mount well cover (typically about 2-inches larger in diameter than the flush-mount well cover).

(b) Place the flush-mount well cover in the center of the core. If needed, cut the skirt so the flush-mount well cover is flush with the floor.

(c) Remove the flush-mount well cover lid, and install the prepared sampling point in the center of the flush-mount well cover by placing it in the flush-mount well cover, so the base is in contact with the sub-base materials. Cut the base of the sampling point, so the top of the point sits just below the lid of the flush-mount well cover.

(d) Install hydraulic cement from the base of the flush-mount well cover up to the base of the ball valve on the sampling point. Then install hydraulic cement or grout/Portland cement between the flush-mount well cover and the concrete slab to match the flush-mount well cover and existing grade.

(e) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(f) Ensure the ball valve is in the closed position before closing the lid. Clean work area. Refer to Photograph 1 for a picture of a newly installed point prior to the placement of the lid.

(g) After vapor point installation, allow sub-surface conditions to stabilize prior to sampling. EPA typically recommends two hours for equilibration; however, the appropriate regulatory guidance associated with the project should be reviewed.

2.1.3 Installation of a Permanent Sub-slab Vapor Point – Stainless-steel Probe Method

This subsection describes the procedure for installing a permanent sub-slab vapor point using a stainless-steel probe, often referred to as the Swagelok® Method. This method was described in a United States Environmental Protection Agency report titled “Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples” (USEPA, 2006). Probes should be constructed prior to ground-intrusive activities.

Sub-slab vapor point installation with a stainless-steel probe does not require concrete coring. Consequently, the Stainless-steel Probe Method is typically less expensive than the Flush-mount Well Cover Method, and is generally recommended in residential settings. Using the Stainless-steel Probe Method, the sample point is largely unprotected. Dirt and debris may fill the sampling point. The threading on the stainless-steel coupling must be clean prior to sampling to ensure a good seal. See Figure B-2 in Attachment B for a cross-sectional diagram of a point installed using the Stainless-steel Probe Method.

Construction: Permanent Stainless-steel Probe Sampling Point

(a) Assemble soil vapor probes using a project-specific length of $^{1}/_{4}$-inch OD stainless-steel tubing connected to the $^{1}/_{4}$-inch compression fitting on a stainless-steel coupling. Install a $^{1}/_{4}$-inch male NPT plug in the female NPT fitting end of the stainless-steel coupling and tighten 270 degrees; this plug will be mounted flush with the ground surface and removed to access the soil vapor probe. See Photograph 2 for a picture of the components.

(b) Decontaminate any cutting oils from the components using Alconox® or equivalent, and rinse with distilled water.

Installation: Permanent Stainless-steel Probe Sampling Point

(a) Using a rotary hammer drill, advance a 1-inch diameter drill hole into the concrete floor to a depth approximately 2 inches below the surface. Photograph 3 is a picture of a typical rotary hammer drill.

(b) Remove the accumulated powdered concrete from the boring using a wet paper towel or vacuum.

(c) Switch to the $^{3}/_{8}$-inch diameter drill bit ($^{3}/_{8}$-inch diameter needed for the $^{1}/_{4}$-inch stainless-steel tubing) and advance the boring through the remainder of the concrete slab and into the sub-slab aggregate. **NOTE:** A different rotary hammer drill than the one used in step (a) will most likely be needed for the $^{3}/_{8}$-inch diameter drill bit. Do not advance the boring greater than 2 inches past the base of the concrete slab. Clean the inside of the boring with a wet towel or similar to remove powdered concrete. In order to eliminate the need for a second, smaller rotary hammer drill, a $^{1}/_{2}$-inch diameter bit can be used provided the probe does not slide down the $^{1}/_{2}$-inch diameter borehole. A decontaminated, stainless-steel washer can be placed at the base of the one-inch diameter borehole to ensure that the probe does not slip down.

(d) Measure the depth of the concrete slab using the drill bits.

(e) Compare the depth of the concrete slab to the length of the assembled probe. The plug should be either flush or very slightly below the surface grade of the concrete slab. Cut the base of the sampling point with a stainless-steel tubing cutter if the probe assembly is longer than the concrete slab is thick. The point should "float" in the concrete slab.

(f) Re-drill using the $^{3}/_{8}$-inch (or $^{1}/_{2}$-inch) diameter drill bit to push any extra concrete powder down the borehole, so it does not interfere when inserting the probe.

(g) Place the probe assembly into the borehole.

(h) Carefully add granular bentonite or a bentonite/cement mix around the probe. Hydrate with distilled water. Use a flat head screwdriver, to mix the bentonite and fill the annulus from the top of the tubing (i.e., the base of the 1-inch diameter borehole) to approximately 1-inch below grade. See Figure B-2 in Attachment B. Use a paper towel to remove excess bentonite.

(i) Photograph 4 is a picture of a point prior to the installation of the hydraulic cement. Install a hydraulic cement cap above the bentonite and below the threads of the plug. Non-shrinking or expanding cements that do not contain VOCs can be substituted.

(j) A 1-inch diameter pronged sink hole cover may be installed over the sampling point for aesthetic purposes, and to reduce the potential for dirt egress into the sampling point. The sink hole cover can be removed with a flat-head screwdriver prior to sampling.

(k) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(l) After vapor point installation, allow sub-surface conditions to stabilize prior to sampling. EPA typically recommends two hours for equilibration; however, the appropriate regulatory guidance associated with the project should be reviewed.

2.1.4 Installation of a Temporary Sub-Slab Soil Vapor Point

This subsection describes the procedure for installing a temporary sub-slab vapor point. See Figure B-4 in Attachment B for a cross-sectional diagram of an installed temporary sub-slab soil vapor sampling point.

Installation Temporary Sub-Slab Soil Vapor Sampling Point

(a) Use the rotary hammer drill to advance the 1-inch diameter drill bit approximately 1-inch into the concrete. See Photograph 3 for a picture of a typical rotary hammer drill.

(b) Remove the accumulated powdered concrete from the boring using a wet paper towel.

(c) Switch to the $^{3}/_{8}$- or $^{1}/_{2}$-inch diameter drill bit and advance the boring through the remainder of the concrete slab and into the sub-slab aggregate. **NOTE:** A different rotary hammer drill than the one used in step (a) will most likely be needed for the $^{3}/_{8}$-inch diameter drill bit. Do not advance the boring more than 2 inches past the base of the concrete slab. Clean the borehole with a wet paper towel; do not use a vacuum which could purge air from the sub-slab and affect the representativeness of the sample.

(d) Install Teflon® or Teflon®-lined polyethylene tubing into the base of the boring. Ensure the tubing is long enough to pass through an inert gas containment structure (if required for leak-testing) and connect to a sampling canister.

(e) Using the dedicated bentonite mixing container, hydrate a sufficient amount of granulated bentonite with distilled water to fill the boring diameter and seal around sampling tube. The bentonite seal will require monitoring as it will begin to dry. Rehydrate as necessary.

(f) Install stopcock, or equivalent, on sample tubing to close the sample point. If materials listed in Section 1.3 are used, sample closure is assembled as described below and illustrated in Photograph 5:

1. Install $^{1}/_{8}$-inch ID Tygon tubing over slip end of stopcock
2. Cut tubing flush with the end of the stopcock.
3. Form a tube-in-tube connection with ¼-inch ID Tygon tubing over $^{1}/_{8}$-inch ID Tygon tubing.
4. Cut ¼-inch ID Tygon tubing to extend approximately 1-inch beyond the end of the stopcock.
5. Form another tube-in-tube connection by placing the open end of the ¼-inch ID Tygon tubing over the ¼-inch Teflon® tubing of the sample point.

(g) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(h) After the vapor point has been installed, adequate time should be allowed for the subsurface to return to equilibrium conditions. The equilibration time will be dependent on the degree of soil disturbance during installation and regulatory requirements. The Project Manager should be consulted to determine the optimal/required equilibration time. Photograph 6 is a photograph of a temporary sub-slab vapor point during sample collection.

Decommission: Temporary Sub-Slab Soil Vapor Sampling Point

After sample collection is complete, decommission the temporary sampling point as described below.

(a) Remove the tubing from the boring.

(b) Either excavate the bentonite seal or push to the base of the boring.

(c) Abandon vapor point boring with non-shrinking grout or cement.

(d) Clean up the work area.

2.1.5 Installation of a Permanent Deep Soil Vapor Point

This subsection describes the procedure for installing a permanent deep soil vapor point. Unlike sub-slab sampling points, deep sampling points may be located at interior or exterior locations. The surficial completion of the point is similar to the sub-slab Flush-mount Well Cover Method; however the sampling point itself is a mesh, stainless-steel screen point, as shown in Photograph 7. See Figure B-3 in Attachment B for a cross-sectional diagram of a permanent deep soil vapor point. Multiple vapor points may be installed in the same borehole.

Construction: Deep Soil Vapor Point

(a) Decontaminate any cutting oils from the stainless-steel components of the vapor point using Alconox® or equivalent, and rinse with distilled water.

(b) Assemble the soil vapor probe using a stainless-steel mesh vapor point and $^{1}/_{4}$-inch OD Teflon® or Teflon®-lined tubing. The stainless-steel mesh vapor point may be constructed with either a compression fitting or a barbed fitting.
   1. Cut the tubing to a length approximately 24-inches longer than the target installation depth.
   2. Connect the tubing to the stainless-steel mesh vapor point. Use Teflon® tape and/or zip ties as appropriate to ensure a good seal.
      i. If a compression fitting is used, slide the nut and ferrule (from the vapor point) over the sample tubing. Insert tubing into the coupling on the vapor point. Slide ferrule down until seated firmly. Connect the nut to the coupling and tighten, but do not over tighten (approximately 270 degrees).
      ii. If a barbed fitting is used, make the tube-in-tube connection and verify tightness.

Installation: Deep Soil Vapor Point

(a) Select drilling location. Verify the utilities have been marked and ensure location is located safely away from subsurface utilities. Hand dig if appropriate. If sampling location has a concrete surface proceed to Step (b) below. If concrete is not present, skip Step (b) and proceed to Step (c) below.

(b) If concrete is present at sampling location, use concrete coring equipment to core through the concrete surface and remove the core. The concrete core should be large enough to set, grout and seal the flush-mount well cover (typically about 2-inches larger in diameter than the flush-mount well cover).

(c) Use direct push drilling technologies (e.g., Geoprobe®) to advance a borehole having a minimum diameter of 3-inches to approximately six inches below the target sampling depth.

(d) Install the deep soil vapor point, assembled as described in the Construction section above, to the total depth through the Geoprobe® rods.

(e) Carefully create a filter pack using appropriately sized glass beads or clean sand to approximately 6-inches above the top of the screened interval, backfilling the deep soil vapor point through the Geoprobe® rods if possible.

(f) Slowly remove rods, being careful not to pull or otherwise disturb the sampling point. Use a clean measuring tape to verify that the height of the filter pack remains at least 6-inches above the top of the screened interval. Add additional filter pack material as appropriate.

(g) A thin (1- to 4-inch) layer of clean medium sand may be placed above the filter pack to help prevent the egress of hydrated granular bentonite into the filter pack.

(h) Seal the well annulus using granular bentonite from the top of the filter pack, or medium sand layer, to a depth of approximately 2 ft. bgs. Place granular bentonite above the filter pack material in 3 to 6-inch lifts. Hydrate each lift in place with distilled water prior to the addition of the next lift to help ensure an effective seal above the monitoring point. If multiple stainless-steel deep soil vapor points are being installed in the same borehole, repeat steps (c) through (h), as necessary.

(i) Seal the remaining well annulus using grout/Portland cement mix, or similar, from approximately 1 to 2 ft. bgs.

(j) Cover and protect the sampling point by installing a 4 to 8-inch flush-mount well cover.

(k) Excavate an area around the borehole as needed to facilitate the installation of the flush-mount well cover.

(l) Open the flush-mount well cover. Being careful not to pull or otherwise disturb the sampling point, extend the sample collection tubing through the center of the flush-mount well cover and place the flush-mount well cover around the sampling point.

(m) The flush-mount well cover should be finished consistent with methods used for flush-mount groundwater monitoring well installations. The protective steel “skirt” should extend approximately 1 foot below the top of the road box. As many flush-mounted vapor points are installed in paved areas, the concrete used to set the flush-mount well cover should be compatible with the bearing capacity of the existing pavement. Depending on location considerations, the concrete may be sloped slightly away from the sampling point or completed truly flush with the surroundings. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole so water that accumulates in the road box will drain. The pad should be sufficiently large to withstand anticipated traffic and weather conditions.

(n) Cut excess tubing and install stopcock, or equivalent, on sample tubing to close the sample point. If materials listed in Section 1.3 are used, refer to Section 2.1.4, Step f and Photograph 5 for assembly description.

(o) Verify sample port is closed and close flush-mount well cover. Clean work area.

(p) Sampling points should be permanently marked with the sampling point identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized.

(q) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(r) After vapor point installation, allow sub-surface conditions to stabilize prior to sampling. EPA typically recommends two hours for equilibration; however, the appropriate regulatory guidance associated with the project should be reviewed.

2.1.6 Installation of a Temporary Deep Soil Vapor Point

This subsection describes the procedure for installing a temporary deep soil vapor point. Unlike sub-slab sampling points, deep sampling points may be located at interior or exterior locations.

Installation: Temporary Deep Soil Vapor Point

(a) Select drilling location. Verify the utilities have been marked and ensure location is located safely away from subsurface utilities. Hand dig, if appropriate, for utility clearance purposes.

(b) Use direct push drilling technologies (e.g., Geoprobe®) to advance a borehole to 3-inches below the target sampling depth.

(c) Install Teflon® or Teflon®-lined polyethylene tubing through Geoprobe® rods to the target sampling depth. Ensure the tubing is long enough to pass through an inert gas containment structure (if required for leak-testing) and connect to a sampling canister.

(d) Carefully create a filter pack using clean sand to approximately 6-inches above the end of the tubing, backfilling the deep soil vapor point through the Geoprobe® rods if possible.

(e) Slowly remove rods, being careful not to pull or otherwise disturb the tubing. Use a clean measuring tape to verify that the height of the filter pack remains at least 6-inches above the end of the tubing. Add additional filter pack material as appropriate.

(f) Seal the well annulus using granular bentonite from the top of the filter pack to a depth of approximately 1 ft. bgs. Place granular bentonite above the filter pack material in 3 to 6-inch lifts. Hydrate each lift in place with distilled water prior to the addition of the next lift to help ensure an effective seal above the monitoring point.

(g) Cut excess tubing and install stopcock, or equivalent, on sample tubing to close the sample point. If materials listed in Section 1.3 are used, refer to Section 2.1.4, Step f and Photograph 5 for assembly description.

(h) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(i) After the vapor point has been installed, adequate time should be allowed for the subsurface to return to equilibrium conditions. The equilibration time will be dependent on the degree of soil disturbance during installation and regulatory requirements. The Project Manager should be consulted to determine the optimal/required equilibration time. Photograph 8 is a picture of a temporary deep soil vapor sampling point at an exterior location.

NOTE: As an alternative to installing temporary deep soil gas points as described above, soil gas samples can be collected in real time during drilling activities using specialty tooling such as the Geoprobe® post-run tubing (PRT) system. Additional information regarding the means and methods of using specialty tooling is available through vendor websites. If using an alternative installation method, the best practices outlined in this SOP should be considered. For example, if collecting samples through reusable tooling, such as the PRT system, care should be taken to ensure equipment is decontaminated between sample locations. Additionally care should be taken to ensure subcontractors do not use materials that may contain VOCs during installation of the temporary sampling point.

Decommission: Temporary Deep Soil Vapor Sampling Point

After sample collection is complete, decommission temporary sampling point as described below.

(a) Remove the tubing from the boring.

(b) Abandon vapor point boring with non-shrinking grout or cement, or other material consistent with surface conditions.

(c) Clean up the work area.

2.2 Active Soil Vapor Sample Collection

2.2.1 Pre-sampling Activities

Pre-sampling activities include, but are not limited to the following:

- Determine the analyses and reporting limits required prior to sampling and communicate with the analytical laboratory. If low reporting limits are required, then the sampling canister may need to be prepared by the laboratory for analysis via SIM or low-level analysis. If SIM analysis is required, it is recommended that each sampling canister be individually certified as clean.
- Determine the size of the sampling canister required and desired flow controller setting (100 to 200 mL per minute is common for soil vapor sampling). Typically 1-liter or smaller canisters are used. Six-liter canisters are often required to achieve the desired reporting limits for indoor air sampling. However smaller sample canisters are typically sufficient to achieve the desired reporting limits for active soil vapor sampling. Six liter canisters are very cumbersome to use and expensive to ship. Additionally 6-liter canisters take longer to fill, and due to the sample

volume, are more likely to exhibit leaks (ambient air short-circuiting) particularly in lower permeability soils.

- Discuss project requirements for leak testing with the Project Manager. Acquire and assemble materials required for applicable leak detection testing, e.g., helium, inert gas containment device, sealing material for quantitative tracer testing.
- Verify that the laboratory analyte list includes the tracer, e.g., 1,1-difluoroethane or helium, if appropriate.
- Order and receive sampling canisters, flow controllers, and duplicate tees from the laboratory. A minimum 2-week lead time is recommended. Because sample canisters are re-used and expensive, laboratory stock is limited. For large projects or for projects in which individually-certified canisters are required, a longer lead time may be needed for the laboratory to fulfill the canister order.
- To the extent reasonable, assemble the sample collection train in advance, e.g., moisture filter and tubing connection from sample point to flow controller. Dirt, wind, cold, etc. can make assembling an air tight sample collection train difficult in the field. Photograph 9 is an example of a pre-assembled moisture filter apparatus than can be used to quickly form a connection with the regulator (equipped with a barbed fitting) and the ¼-inch sample collection point.
- Sampling equipment should be inspected prior to sampling. Sampling equipment provided by the laboratory typically includes an analog pressure gauge on the canister and/or the flow controller. See Photographs 10, 11, and 12 for examples.
    - The vacuum of the sampling canisters should be recorded in the field prior to sampling using the analog gauge provided by the laboratory. If the vacuum is less than 25 inches of mercury (in. Hg), the sampling canister should not be used because this indicates a potential leak. The sampling canister vacuum may also be checked with a digital vacuum gauge, which can be more accurate than the analog gauges provided by the laboratory.
    - Check the documentation attached to the flow controller to verify the flow rate has been set to the correct flow rate, typically between 100 and 200 mL/min.
- Use sample point construction documentation to determine the purge volume.
- Label the tag on the sampling canister with the pertinent sampling data, as well as the flow controller number.
- A clean pair of new, non-powdered, disposable gloves should be worn each time a different location is sampled, and the gloves should be donned immediately prior to sampling. The gloves should be changed any time during sample collection when their cleanliness may be compromised.

2.2.2 Connection of Flow Controller to Sampling Canister

The connection between the soil vapor flow controller and the sampling canister is likely to vary between laboratories. Be sure to follow the laboratory-provided directions when connecting the flow controller to the sampling canister. Photographs 10, 11, and 12 show several common soil vapor flow controllers and sampling canisters. Quick connect fittings are typically simple and trouble-free, whereas compression type fittings are more common, but may also be more troublesome due to preexisting imperceptible damage, i.e., minor abrasions caused by dust/dirt and/or deformation caused by overtightening. Common suggestions for connecting the flow controller to the sampling canister using compression type fittings are as follows:

(a) Confirm the valve is closed (knob should already be tightened clockwise), before unthreading the stainless-steel plug from the top of the canister.

(b) Check to see that the O-ring is still in place prior to making the connection. Ensure extra O-rings and ferrules are shipped with the flow controller in case they are damaged or missing.

(c) If present, remove the plastic cap from the flow controller outlet (male threads) before attempting to connect to the inlet on the sampling canister.

(d) Do not over tighten compression fittings.

2.2.3 Purge Sample Collection Point

The following section describes the procedure for purging the sample collection point prior to sample collection. In order to ensure a representative sample is collected, at least one purge volume should be removed prior to inert gas testing and three purge volumes should be removed prior to sample collection. However, no more than five purge volumes should be removed prior to sample collection. Both under purging and over purging can affect the representativeness of the sample, and create a low bias. If the project scope includes field screening/measurements with a PID, FID, and/or landfill gas meter, caution should be used regarding the number of purge volumes being removed during these measurements. In order to control the potential for over purging, field screening can be completed concurrent with sample point purging (after one purge volume has been removed). Alternatively field measurements may be collected after sample collection has been completed.

(a) Calculate the volume of air in the sample point and sample collection tubing or refer to Table 1 for pre-calculated volumes for select tubing sizes.

$$V_{tubing} = (\pi r_t^2 h_t)$$

Where:

$\pi = 3.14159265$

r_t = radius of the inner diameter of tubing (inches)

h_t = length of tubing (inches)

V_{tubing} = volume of air in entire length of tubing (in^3)

Table 1: Purge Volumes for Select Tubing/Vapor Point Sizes

Tubing/Vapor Point Size (inches ID)	Volume/ft (milliliters/ft)
$^3/_{16}$	5.4
$^1/_4$	10
$^3/_8$	22
$^3/_4$	39
$^1/_2$	87
1	150
2	620
4	2,470
6	5,560
ID = Inner Diameter	

$V_{vapor\ probe} = (\pi r_{vp}^2 h_{vp})$

Where:

r_{vp} = radius of the inner diameter of vapor point (inches)
h_{vp} = length of vapor point (inches)
$V_{vapor\ probe}$ = volume of air in entire length of vapor probe (in^3)

$V_{filter\ pack\text{-}air} = \eta * [\pi r_{fp}^2 h_{fp} - V_{vapor\ probe}]$

Where:

η = air-filled porosity of the filter pack (typically 0.3 to 0.4)
r_{fp} = radius of the filter pack (inches)
h_{fp} = length of the filter pack (inches) – Refer to sample point construction details
$V_{filter\ pack\text{-}air}$ = air-filled volume of the filter pack (in^3)

$V_T = V_{tubing} + V_{vapor\ probe} + V_{filter\ pack}$

Where:
V_T = Total volume of air in the sample point, e.g., tubing, sampling probe, and filter pack (if present)
Convert in^3 to mL (1 in^3 = 16.387 mL)

(b) If applicable, use an air flow rate meter (Dry Cal® or equivalent) to determine the flow rate of the purge pump. Using tubing, connect the purge pump to the outlet of the flow rate meter. The type of tubing used here is optional; the only requirement is that there is a good fit in order to obtain an accurate flow rate reading. Record the flow rate of the purge pump (mL/min). Note: For low volume sample points (e.g., sub-slab points which typically have a total volume <200 mL) a graduated 50 mL manual syringe may be used as an alternative to a purge pump.

(c) If applicable, calculate the time required to purge one purge volume based on the flow rate of the purge pump (Note: If used, the inert gas detector may also be used as the purge pump).

Where

V_T in mL (calculated above) / purge pump flow rate (mL/min) *60 seconds/1 minute = Number of seconds required to purge one purge volume

(d) Connect the purge pump or syringe to the sample collection point.

(e) Use the purge pump or syringe to purge the sample point. If applicable, remove at least one sample point volume prior to inert gas tracer testing and/or field screening/measurements. Remove at least 3 sample point volumes and no more than 5 sample point volumes prior to sample collection.

(f) Disconnect purge pump or syringe from the sample point. Immediately connect the sample collection apparatus to the sample point and proceed with leak testing and sample collection as described in Section 2.2.4 and Section 2.2.5 below.

2.2.4 Leak Testing

Leak testing is performed to verify that a representative sample is collected. Leaks may occur in the sample collection train and/or the soil vapor sample point itself. ***Leak testing to verify the integrity of both the sample collection train and the soil vapor sample point itself must be completed for every soil vapor sample in order to establish air tightness***. Leak testing of the sample collection train can be completed through a shut-in leak test. Leak testing using a tracer gas, referred to as tracer testing in this SOP, is typically used to test the integrity of the soil vapor sampling point itself, although it can also be used to test the integrity of the sampling train. Tracer testing may be either quantitative (e.g., helium) or semi-quantitative (e.g., 1,1-difluoroethane). Quantitative tracer testing is typically more difficult and labor intensive than the use of a semi-quantitative tracer. The selection of the appropriate tracer is dependent on project objectives and regulatory requirements. For example, in the State of New York, use of a quantitative tracer is required to verify the sample point integrity prior to each sampling event. For projects where state requirements do not mandate the use of a quantitative tracer, a semi-quantitative tracer may be appropriate and more cost effective. When permanent sampling points are installed, it may be appropriate to use a quantitative tracer to verify initial sample point integrity, and a semi-quantitative tracer may be used during subsequent sampling events to document that the sampling point integrity has not been compromised.

Attachment D describes recommended methods for completing leak testing to verify the integrity of the sample collection train prior to sample collection, as well as options for either semi-quantitative leak testing or quantitative leak testing to verify soil vapor sampling point integrity. Leak testing is required. However the leak-testing methods described in Attachment D are recommendations only. Actual leak test methods may vary based on project objectives and regulatory requirements.

2.2.5 Vapor Sample Collection

(a) Connect the flow controller to the canister as described in Section 2.2.2 and assemble the sample collection train. Depending on the sample set up, the sample collection train will typically include the following: the sampling canister, the flow controller, a moisture filter, a stopcock, as well as appropriate fittings and inert tubing (e.g., Teflon®, Teflon®-lined, or Nylaflow®) to connect these components. For an example, see Photograph 13. For duplicate samples a laboratory provided duplicate tee will also be included (see Photograph 14).

(b) On permanent sampling points, open/prepare the sample collection point as appropriate.

1. For permanent points protected with a road box or flush-mount well cover, open the lid to inspect the hydraulic cement or grout/Portland cement seal between the sampling point and the flush-mount well cover. Inspect seal between the concrete floor (or other surface material) and the flush-mount well cover. If the seal is visibly compromised, then place granular bentonite in the void(s) and hydrate.

2. For permanent points installed via the Stainless-steel Probe Method, remove sink hole cover (if present). Remove plug using a $^{7}/_{16}$–inch socket and thread a male/male coupling (see Photograph 2) onto the permanent point. Lock the ferrule and the nut to the sample tubing, then connect the sample tubing to the top of the coupling (do not

use a wrench; this connection should be hand tight). Inspect the seal, if visibly compromised, then place additional granular bentonite in the void and hydrate.

(c) Purge the sample collection point as described in Section 2.2.3. Remove at least one sample point volume prior to inert gas tracer testing and/or field screening/measurements. Remove at least 3 sample point volumes and no more than 5 sample point volumes prior to sample collection.

(d) If applicable, field screening/measurements with a PID, FID, and/or landfill gas meter may be collected while the sample collection point is purged.

(e) Complete project-specific leak testing as described in Section 2.2.4. Leak testing to verify the air tightness of **both** the sample collection point and the sample collection apparatus is required. Sample point integrity is tested with **either** quantitative (inert gas) tracer testing or with semi-quantitative tracer testing, not both. Quantitative (inert gas) tracer testing is typically completed immediately after purging and prior to the shut-in leak test (to verify the integrity of sample collection train). By contrast, semi-quantitative tracer testing is completed concurrent with sample collection. Detailed procedures for recommended leak test options are provided in Attachment D.

(f) During pre-sampling leak testing procedures, the sample collection apparatus should be connected to the sample collection point. Verify the integrity of this connection, and tighten as appropriate.

(g) Open the sampling canister valve to begin sampling. Record the start time, flow controller rate, initial vacuum, and sampling canister size.

(h) Depending upon the soil type, the sampling canister may fill slower than anticipated based on the flow controller setting. It is preferable to wait until the vacuum reaches no more than 6 in. Hg, rather than wait a specified time period. Note, if vacuum fails to drop, this may be the result of tight soils, cold weather, or other equipment-related issues, which may require troubleshooting. If the problem cannot be resolved, contact the Project Manager to determine how to proceed, as the canister is not filling properly and inadequate sample volume may lead to elevated reporting limits and potential issues with the representativeness of the sample. Note that the final target vacuum may vary depending on the project and regulatory requirements. Verify appropriate requirements prior to collecting samples.

(i) When the canister reaches the final target vacuum, the sampling canister valve can be closed. Record the final vacuum and time the valve was closed.

(j) Remove the tracer gas containment device.

(k) Disconnect the sample collection apparatus from the sample collection point. Dismantle apparatus, and dispose of tubing, moisture filter, etc.

(l) Close permanent sample collection points or decommission temporary sampling points.

1. On permanent sub-slab points installed via the Flush-mount Well Cover Method, verify that the ball valve is in the off (closed) position and re-install the lid to close the sample collection point.

2. On permanent sub-slab points installed via the Stainless-Steel Probe Method, remove the tubing connected to the soil vapor probe and replace the plug. Hand tighten the threads of the plug, and then tighten slightly with a $^{7}/_{16}$-inch socket. Do not over-tighten the plug, or the point may be damaged by the force of threading/unthreading the plug. Replace the sink hole cover (if present).

3. On permanent deep soil vapor points, verify that the stopcock is in the off (closed) position and re-install the lid to close the sample collection point.

4. On temporary sub-slab soil vapor sampling points, decommission the sampling point as described in Section 2.1.5.

5. On temporary deep soil vapor sampling points, decommission the sampling point as described in Section 2.1.6.

(m) Clean up the work area.

2.2.6 Post-sampling Activities

(a) Check the label on each sample.

(b) Re-install cap or plug on sample canister for shipment. Package canisters for shipment consistent with packaging upon receipt from the laboratory.

(c) Complete the chain-of-custody. Verify that the analyte list includes the tracer, if applicable.

(d) Air samples do not need to be refrigerated or shipped on ice.

(e) Ensure samples are delivered to the laboratory well before the required holding time expires.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of specific field quality control (QC) samples will be specified in the project-specific planning documents and may include one or more of the following samples: background/ambient samples, equipment blanks, and field duplicates.

4.1 Background or Ambient Sample

A background or ambient sample is an ambient air sample collected outside in the area proximate to the site. Analysis of the background or ambient sample can provide information about the ambient levels of site contaminants.

4.2 Equipment Blank

An equipment or material blank may be used to provide information about the levels of contaminants present in materials used to collect soil vapor. An equipment blank is collected by pulling ambient air through a constructed soil vapor probe and all relevant components of the soil collection train (e.g., moisture filter, tubing, etc.) prior to installation. If an equipment blank is collected, a background or ambient air sample, described in Section 4.1 above, must also be collected so that contaminants attributable to the sample point may be distinguished from contaminants present in ambient air.

4.3 Field Duplicates

The following procedures should be used for collecting field duplicates of soil vapor samples:

(a) For quality control purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a non-existing sample identification will be assigned in labeling the duplicate. Labeling procedures used for sampling will be employed, and all parameters measured will also be recorded. Since the duplicate is collected simultaneously with the actual sample, a "blind" sample time, typically within 1 hour of the actual time, will also be assigned. The actual source and collection time of the duplicate sample will be recorded in the field book.

(b) Each duplicate sample will be collected by installing a T-connection (made of Teflon®, stainless-steel, or brass) at the end of the sample tubing and connecting one sampling canister to each side of the connector. Both sampling canister valves must be opened and closed at the same time. Photograph 15 is a picture of a duplicate sample being collected. Typically duplicate tees can be provided by the analytical laboratory upon request (Photograph 14).

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

5.1 Sample Point Installation

Record the general sample point installation information in the field book or on a field form. An example field form is provided in Attachment C. At a minimum, field documentation must include the following information:

- Sample point identification number
- Sample location (sketch of the sample point)
- Date/time of installation
- Technician(s) names, including subcontractors
- Slab thickness, if applicable
- Construction details including the following:
    - Installation method
    - Diameter and depth of borehole
    - Composition of probe, sealing, and finishing materials (to document that inert, VOC-free materials were used)
    - Material size including diameter and length/thickness (to allow purge volume to be calculated)
- Field screening results, if applicable
- Decontamination procedure, if applicable
- Presence of any materials that may interfere with soil vapor results

Representative tasks and the condition of areas within the area where soil vapor points are installed should be photographed.

5.2 Sample Collection

Record the general sample collection information, such as location, identification, and date/time in the field book or on a field form. Typical field documentation recorded in a field book may include the following information:

- Sampling canister ID
- Flow controller ID
- Initial vacuum
- Final vacuum
- Sample identification number
- Sample location (sketch of the sample point)
- Leak-test method(s) and applicable data associated with leak-testing, e.g., tracer used, final inert gas concentration detected in sample tubing, etc.
- Time and date sample collection started
- Time and date sample collection ended
- Personnel performing the task
- Volume of vapor purged prior to sampling
- Flow rate of purge pump and flow controller, if applicable
- Weather conditions during sampling
- Field screening results, if applicable
- Decontamination procedure, if applicable
- Analytical parameters
- Heating and air conditioning systems in use at the facility at the time of sampling (e.g., type of system, primary fuel, location of boiler/furnace, type of air conditioning, and air distribution system)
- Barometric pressure at sample collection start

- Barometric pressure at sample collection end
- Presence of any materials that may interfere with soil vapor results

Representative tasks and the condition of areas within the area where soil vapor sampling is performed should be photographed.

All sample numbers must be documented on the chain-of-custody form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

H&P Mobile Geochemistry, Inc., 2013. Evaluation of Leak Check Procedures for Soil Vapor Sampling. Presented at AEHS in San Diego, California on March 20, 2013.

NYSDOH, 2006. Guidance for Evaluating Soil Vapor Intrusion in the State of New York, New York State Department of Health. October 2006.

USEPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples. EPA/600/R-05/147. March 2006.

USEPA, 2007. Construction and Installation of Permanent Sub-slab Soil Gas Wells. SOP 2082. March 29, 2007.

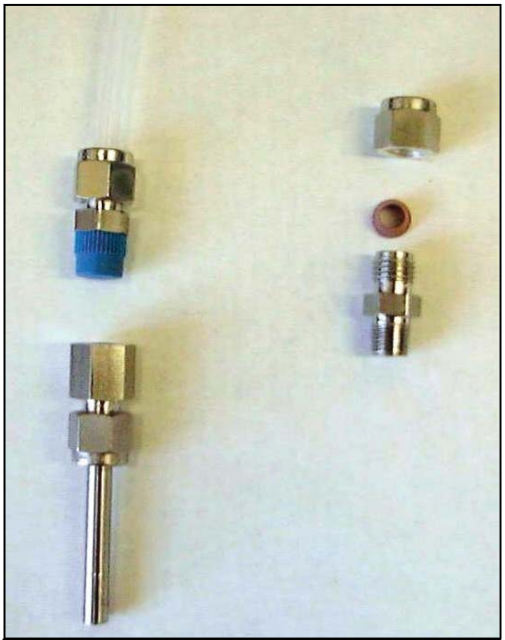
USEPA, 2015. OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, EPA OSWER Publication 9200.2-154. June 2015.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JULY 2016	NOT APPLICABLE

Attachment A:
Photographs

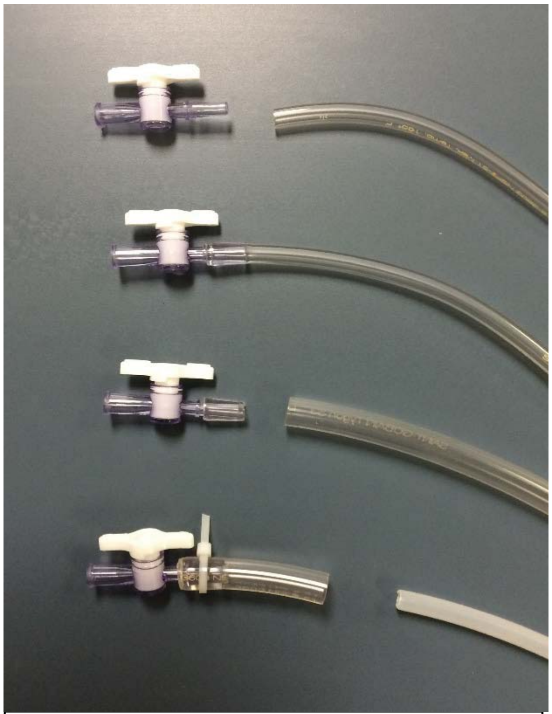
Photograph 1 - Overhead view of completed point via Flush-mount Well Cover Method



Photograph 2 - Stainless-steel Probe Method components

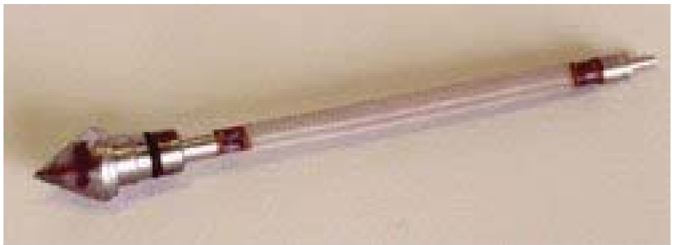
Photograph 3 – Rotary hammer drill

Photograph 4 - Plug and fitting on stainless-steel probe before installation of cement seal



Photograph 5 – Step-by-step process for assembling the end of a deep or temporary sampling point

Photograph 6 – Sample collection at temporary sub-slab vapor point



Photograph 7 – Stainless-steel mesh soil vapor point

Photograph 8 – Soil gas sampling set up at deep, exterior temporary soil vapor point

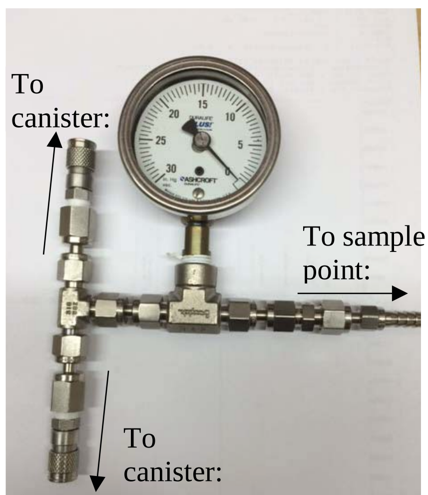
Photograph 9 – Inline moisture filter and stopcock assembly (See Photograph 13, Item [C])

Photograph 10 – One-liter sampling canister with quick connect fitting (See Photograph 13, Item [A])

Photograph 11 – Flow controller with quick connect fitting to canister and barbed fitting to vapor point (See Photograph 13, Item [B])

Photograph 12 - Flow Controller and Sampling Canister
Flow controller (top) with inlet at top and outlet at base. Sampling Canister (bottom) with inlet at top. Note inverted nut at inlet of canister which threads onto flow controller outlet.

Photograph 13 – Soil gas sample collection set up at deep soil gas vapor point prior to placement of shroud for tracer testing.



Photograph 14 – Duplicate tee with quick connect fittings

Photograph 15 - Field duplicate sample collection setup

Photograph 16 - MGD-2002 Helium detector

Photograph 17 - T-connection for quantitative tracer gas

Photograph 18 – Exterior soil gas sampling point with moisture filter setup to begin shut-in leak test

Photograph 19 - Soil gas sampling set up with semi-quantitative leak testing applied via rags draped over vapor point and sampling apparatus.
Note: Although rags are placed around fittings here, a single rag placed immediately adjacent to the sampling apparatus is sufficient when using the Rag Method to apply a semi-quantitative tracer.

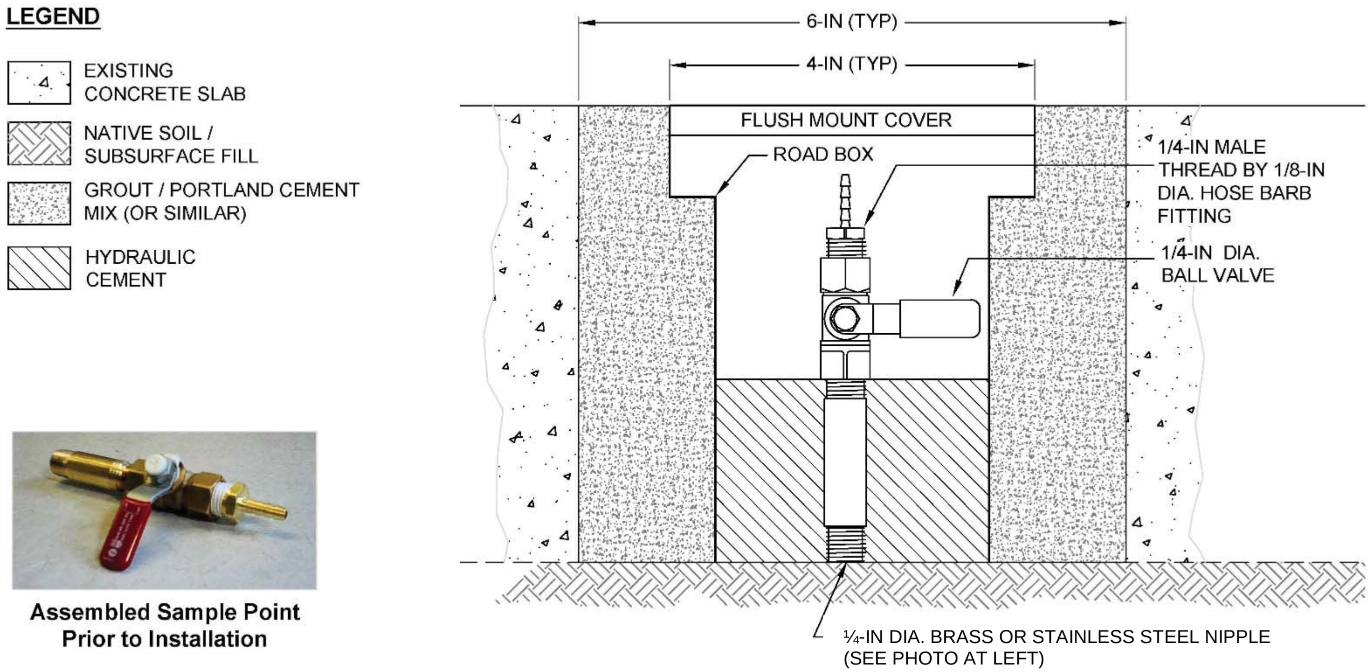
Photograph 20 – Soil gas sample collection set up at deep soil gas vapor point with shroud to contain 1,1-difluoroethane tracer during sample collection.

Photograph 21 - Plastic wrap leak detection method during sampling

Photograph 22 - Inverted container leak detection method with helium tank in background (right). Leak detection for vapor point only, canister outside of container.

Photograph 23 - Inverted container leak detection method with canister inside of container. Leak detection for vapor point and sample collection apparatus. Helium tank to the left of container.

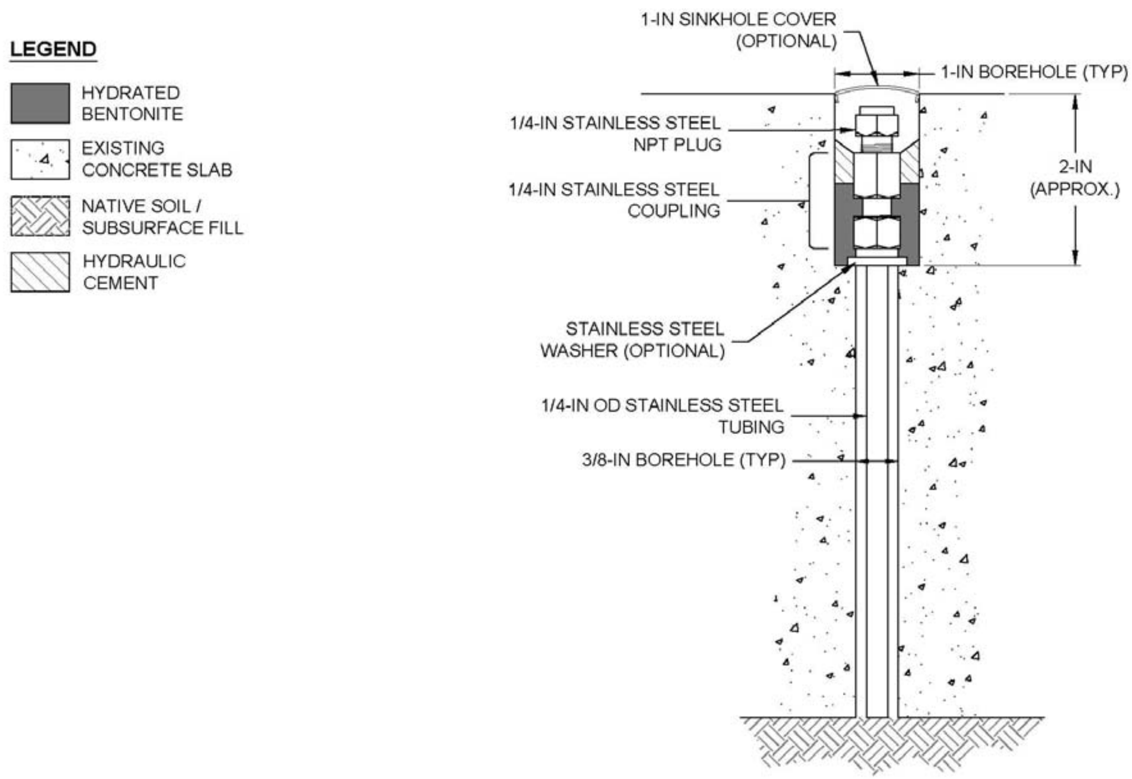
Attachment B: Soil Vapor Point Cross-Sectional Diagrams



CROSS-SECTION OF SUB-SLAB VAPOR POINT
FLUSH MOUNT WELL COVER CONSTRUCTION
TYPICAL INSTALLATION DETAIL
NOT TO SCALE

Figure B-1

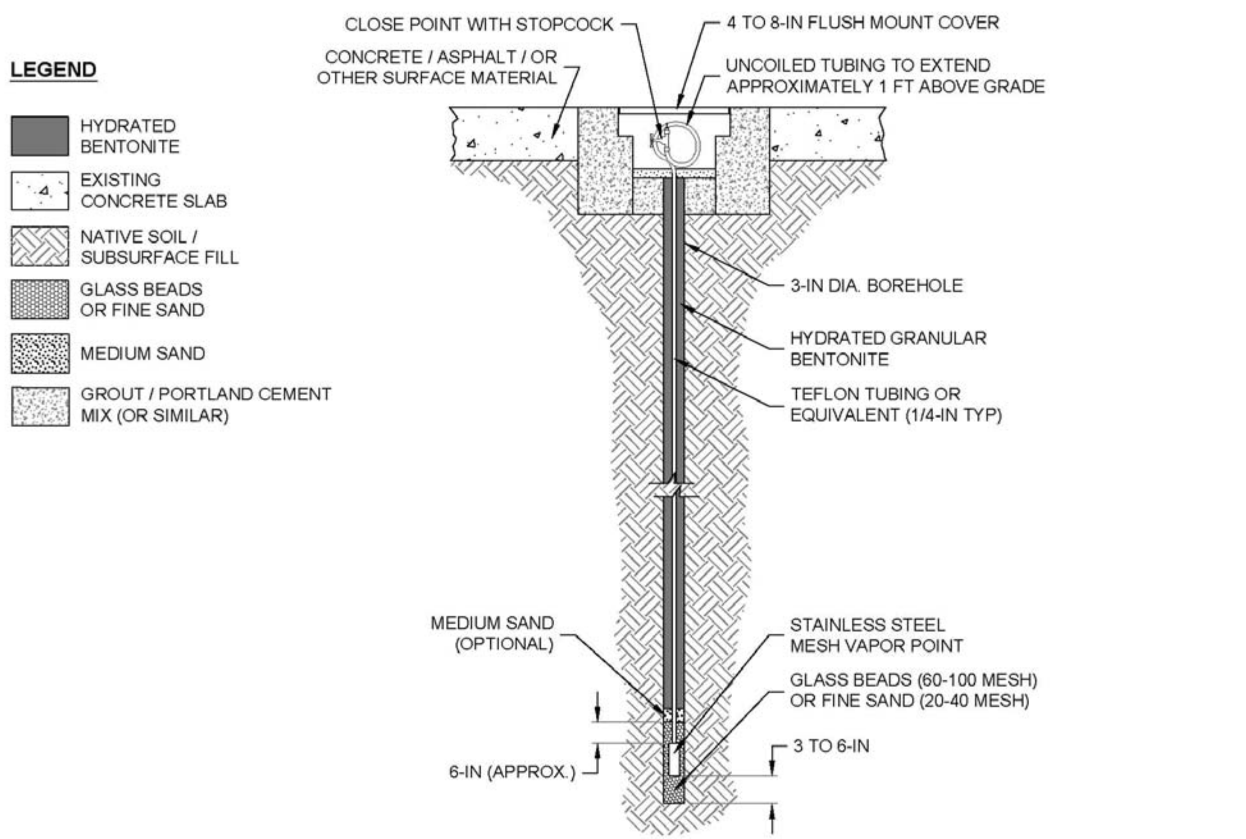
J:\PM SMetz_Soil Gas SOP\SG SOP Figs.dwg



CROSS-SECTION OF SUB-SLAB VAPOR POINT
PERMANENT STAINLESS STEEL PROBE CONSTRUCTION
TYPICAL INSTALLATION DETAIL
NOT TO SCALE

Figure B-2

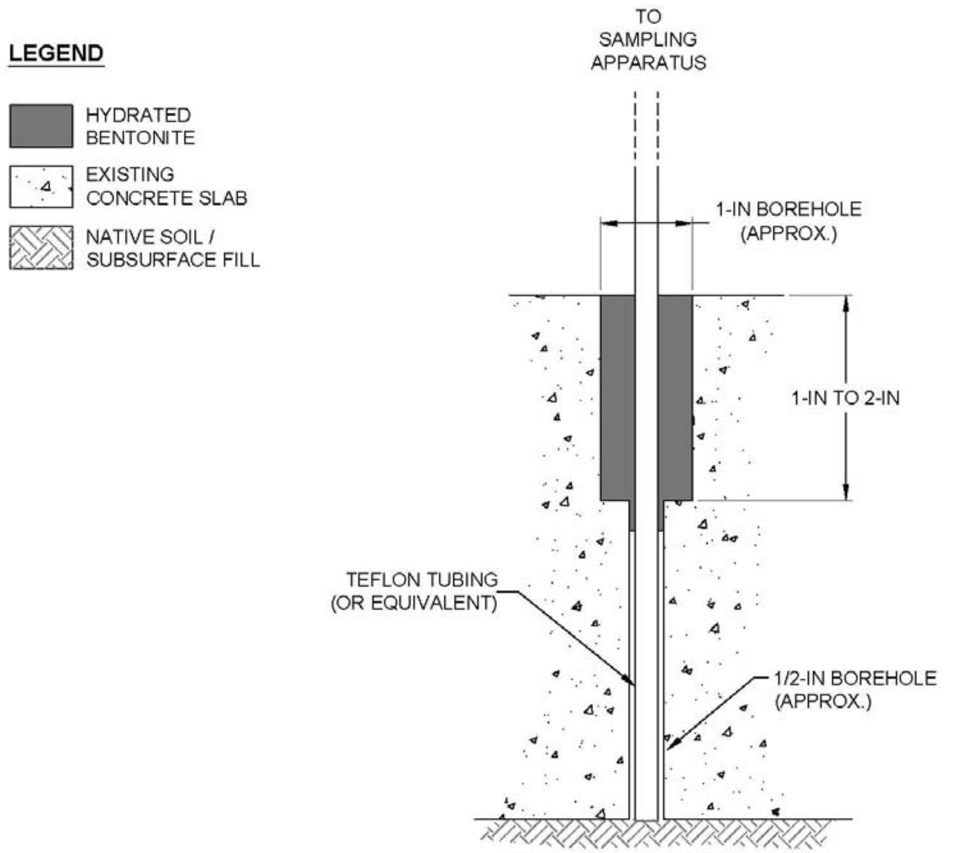
J:\PM SMetz_Soil Gas SOP\SG SOP Figs.dwg



CROSS-SECTION OF DEEP VAPOR POINT
PERMANENT CONSTRUCTION
TYPICAL INSTALLATION DETAIL
NOT TO SCALE

Figure B-3

J:\PM SMetz_Soil Gas SOP\SG SOP Figs.dwg



CROSS-SECTION OF SUB-SLAB VAPOR POINT TEMPORARY LOCATION CONSTRUCTION TYPICAL INSTALLATION DETAIL

NOT TO SCALE

Figure B-4

J:\PM SMetz_Soil Gas SOP\SG SOP Figs.dwg

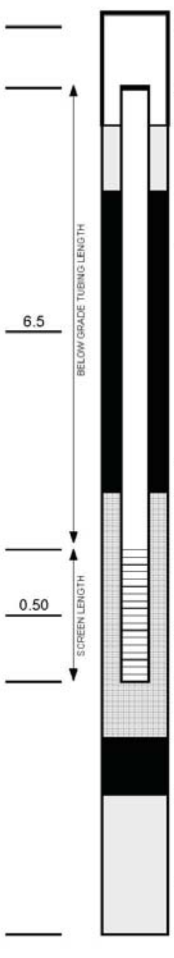
Attachment C:
Soil Vapor Point Installation and Sampling Field Forms

SOIL GAS SAMPLE POINT CONSTRUCTION DIAGRAM

PROJ. NAME: EXAMPLE FORM			POINT ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:		CHECKED BY:

ELEVATION (BENCHMARK: USGS)

DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)



- 0.0 GROUND SURFACE
- 0.5 TOP OF SURFACE PLUG
- 1.0 BOTTOM OF SURFACE PLUG
- SURFACE PLUG MATERIAL: CEMENT
- SEAL MATERIAL: GRANULAR BENTONITE
- 6.0 BENTONITE SEAL
- 6.5 TOP OF SCREEN
- FILTER PACK MATERIAL: GLASS BEADS
- 7.0 BOTTOM OF SCREEN
- 7.5 BOTTOM OF FILTER PACK
- NA BENTONITE PLUG
- BACKFILL MATERIAL: NA
- 7.5 HOLE BOTTOM

SAMPLE POINT DETAILS

MATERIAL: TEFLON TUBING

TUBING SIZE: 1/4" OD

SCREEN TYPE: 6" STAINLESS STEEL IMPLANT

SCREEN MATERIAL WIRE MESH

BOREHOLE DIAMETER: 3 IN. FROM 0 TO 7.5 FT.

SURF. CASING DIAMETER: 4 IN. FROM 0 TO 8 IN.

SUBSURFACE CONDITIONS:

Concrete is 8-inches thick.

Subase is fill composed of gravel, sand and silt

CONSTRUCTION NOTES:

Tubing extends 18-inches above grade to facilitate connection to sampling canister.

Sample point finished with a polyethylene stop cock to close sample point.

PROTECTIVE COVER DETAILS

PERMANENT, LEGIBLE LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER INSTALLED? ☑ YES ☐ NO

REVISED 03/2016

RECORD OF VAPOR SAMPLING

Date____________________ **Project Number**____________________

Project Name____________________ **Field Personnel**____________________

Probe ID____________________ **Probe Depth**____________________

Drilling Contractor____________________ **Weather**____________________

Shut In Test

Test Start Time (HH:MM:SS)________________ **Vacuum at Start**________________

Test Stop Time________________ **Vacuum at End**____________ **Pass?**____________

QUANTIATIVE (HELIUM) TRACER TEST (Shroud)

Note: Perform helium or semi-quantitative tracer test

Test	Time	Helium Concentration	Units (% or ppm_v)	Notes
Shroud Atmosphere				
Sampling Train				

Helium concentration within sampling train should be less than 10% of shroud atmosphere concentration.
If seal or probe needs to be reset then record 2nd attempt below.

Retest (if applicable)	Time	Helium Concentration	Units (% or ppm_v)	Notes
Shroud Atmosphere				
Sampling Train				

SEMI-QUANTITATIVE TRACER TEST

Note: Perform helium or semi-quantitative tracer test

Tracer Type (DFA or Isopropyl)________________ **Method (Rag or Container)**________________

Location of Tracer (On or Adjacent to Sampling Apparatus)________________ **Completed?**____________

VAPOR PURGING CALCULATION

Sub-Slab Point

ONE PURGE VOLUME (mL) = $V_T + V_P$

WHERE $V_T = (3.14 * R_T^2 * H_T)$

AND $V_P = (3.14 * R_p^2 * H_P)$

Soil Gas Point

ONE PURGE VOLUME (mL) = $V_T + V_P + V_{FP}$

WHERE $V_T = (3.14 * R_T^2 * H_T)$

AND $V_P = (3.14 * R_p^2 * H_P)$

AND $V_{FP} = \eta * [3.14 * R_{fp}^2 * H_{fp} - V_p]$

****KEEP UNITS OF LENGTH CONSISTENT, USE CM (1 CM^3 = 1 ML) OR TO CONVERT IN^3 TO ML MULTIPLY BY 16.39****

V – Volume of air in mL (V_T – in tubing; V_p – in probe, V_{FP} – in filter pack)
R – Radius (V_T – of tubing; R_p – of inner diameter of point, R_{FP} – of outer diameter of filter pack)
H – Height (H_p – of vapor point, H_{FP} – of filter pack)
cm – centimeter; mL – milliliter; in - inches
η – air-filled porosity of the filter pack (typically 0.3 to 0.4)

Purge Rate (mL/min)________________ **One Purge Volume (mL)**________________

Purge Time (min)________________ **Total Volume Purged (mL)**________________

Refer to Table 1 in the SOP document for guidance determining volumes of various tubing and probe diameters.
Purge 2-5 purge volumes prior to sample collection (if applicable complete purging during inert gas readings).

VAPOR SAMPLING

Canister I.D.________________ **Flow Controller I.D.**________________

Start Time________________ **Initial Vacuum Pressure in Sample Canister**____________ in Hg

Stop Time________________ **Final Vacuum Pressure in Sample Canister**____________ in Hg

Sample I.D.________________ **Laboratory**________________

Attachment D:
Detailed Leak Testing Procedures

D.1 Overview

Leak testing is performed to verify that a representative sample is collected. Leaks may occur in the sample collection train and/or the soil vapor sample point itself. ***Leak testing to verify the integrity of both the sample collection train and the soil vapor sample point itself must be completed for every sub-slab vapor sample in order to establish air tightness***. Leak testing of the sample collection train can be completed through a shut-in leak test. Leak testing using a tracer gas, referred to as tracer testing in this SOP, is typically used to test the integrity of the soil vapor sampling point itself, although it can also be used to test the integrity of the sampling train. Tracer testing may be either quantitative (e.g., helium) or semi-quantitative (e.g., 1,1-difluoroethane). Quantitative tracer testing is typically more difficult and labor intensive than the use of a semi-quantitative tracer. The selection of the appropriate tracer is dependent on project objectives and regulatory requirements. For example in the State of New York, use of a quantitative tracer is required to verify the sample point integrity prior to each sampling event. For projects where state requirements do not mandate the use of a quantitative tracer, a semi- quantitative tracer may be appropriate and more cost effective. When permanent sampling points are installed, it may be appropriate to use a quantitative tracer to verify initial sample point integrity, and a semi-quantitative tracer may be used during subsequent sampling events to document that the sampling point integrity has not been compromised.

This attachment describes recommended methods for completing leak testing to verify the integrity of the sample collection train prior to sample collection, as well as options for either semi-quantitative leak testing or quantitative leak testing to verify soil vapor sampling point integrity. However the leak-testing methods described in this section are recommendations only. **Actual leak test methods may vary based on project objectives and regulatory requirements.**

D.2 Equipment for Leak-Testing

Shut-In Leak Test:

- Assembled sample collection train, including sampling canister, flow controller, and all other components necessary for sample collection. See Section 2.2.2 of this SOP.
- Stopcock or ball valve (may be part of sample collection train or sample collection point) to close sample collection train
- Vacuum gauge (typically an integral component of the sampling canister and/or the flow controller)
- Zip ties
- Wrenches or other tools necessary to tighten fittings
- Teflon tape (not to be used with compression fittings)
- Watch or timer (capable of monitoring time to the nearest second)

Semi-Quantitative (Inert Gas) Tracer Gas Testing:

- Assembled sample collection train, including sampling canister, flow controller, and all other components necessary for sample collection. See Section 2.2.2 of this SOP.
- Tracer (1,1-difluoroethane [electronic dusting spray, verify composition prior to use] is recommended; isopropyl alcohol may also be used)
- Rag (for rag method)
- Ziploc bag (for rag method)
- Large clear plastic bags (often marketed as recycling bags) (for container method)

- Weight(s) or similar to weigh down plastic bag (for container method)
- Duct tape (for container method)
- Paper towels (for container method)
- Distilled water (for container method)

Quantitative (Inert Gas) Tracer Gas Testing:

- Inert gas detector (e.g., Radiodetection® MGD-2002 for helium – See Photograph 16)
- Air flow meter (e.g., DryCal® DC-Lite)
- Polyethylene tubing to transfer inert gas to containment structure
- Stainless-steel T-connector with associated fittings for tubing (optional) – See Photograph 17
  - One – $^1/_4$-inch OD stainless-steel tee
  - Two – $^1/_4$-inch OD stainless-steel port connector
  - Five – $^1/_4$-inch stainless-steel nut and ferrule
  - One – $^1/_4$-inch OD stainless-steel ball valve
- Tubing and fittings necessary to form an air-tight connection between the inert gas detector and the sample collection port
- Wrenches or other tools necessary to tighten fittings
- Teflon® tape (not to be used with compression fittings)
- Zip ties
- High purity or ultra-high purity inert gas (e.g., helium) with tank regulator
- Tracer gas containment:
  - Plastic or stainless-steel container or
  - Plastic wrap
- Granular bentonite
- Drill and bits (if inverted container is used)
- Distilled water
- Paper towels
- Weather-stripping (if inverted container is used)
- Duct tape

D.3 Leak Test to Verify Air Tightness of Sample Collection Train, i.e., Shut-In Leak Test

Leak testing to verify the integrity of the sample collection train is required. This section describes a shut-in test, which is recommended to meet this objective. The shut-in leak test should include all fittings and connections between the sample canister and the sample port, including the moisture filter. Note, if the entire sample collection train is enclosed in the tracer containment device, tracer testing (described below) may also be used to verify the integrity of the sample collection train. The shut-in leak test is recommended because it allows the integrity of the sample collection train to be verified prior to sample collection and analysis.

a. Connect the flow controller to the canister, as described in Section 2.2.2.
b. Connect the moisture filter, if used, and any other necessary sampling components as described in Section 2.2.5(a).
c. Check all fittings and connections. With the exception of compression fittings, use Teflon® tape on threaded fittings and zip ties to help ensure tube-in-tube and barbed fitting connections are air-tight.

d. Purge sample collection point as described in Section 2.2.3, and immediately connect the sampling apparatus to the soil vapor sample point (or tee connection for quantitative tracer, see below, if applicable). Cover the end of the tubing when changing the tubing over so ambient air does not enter the sample tubing.
e. If applicable, complete quantitative (inert gas) tracer gas testing as described in Section D.5 below.
f. Verify that the stopcock, ball valve or tee on the sampling point is closed. If the sample point does not have a stopcock (or equivalent), include a stopcock in the sample collection train as near as possible to the soil collection point, so that that flow between the soil vapor sampling point and sample canister can be interrupted, yet the air tightness of all other fittings and connections is tested by the shut-in leak test (Photograph 18).
g. Note the initial vacuum (It should be 0 if the vacuum gauge is on the flow controller, or it should be between 25 and 29 inches Hg if the vacuum gauge is on the sample canister itself).
h. Open the valve on the canister. Record the initial vacuum and time. If the vacuum gauge is on the flow controller, the vacuum reading on the gauge should immediately increase to between 25 and 29 inches Hg. If the vacuum gauge is on the sample canister, the vacuum reading on the gauge may decrease slightly (<1 inches Hg) as air in the sample collection train enters the canister.
i. If any of the fittings are not air-tight, there will be a noticeable reduction in the vacuum reading when compared to the initial vacuum reading. If the fittings are air-tight, the vacuum will not change.
j. Monitor the vacuum reading for period of time sufficient to observe a noticeable drop in vacuum, e.g., a period sufficient to fill approximately 10 to 20-percent of the canister. This period will vary depending on the size of the sample canister and the flow controller setting. One minute is sufficient for a 1-liter canister paired with a 200 mL/min flow controller. The duration of the shut-in test should increase if the canister size is larger and/or if the flow rate is lower.
k. If the vacuum does not change, the sampling apparatus has passed the shut-in test. If the vacuum does change, the sampling apparatus has failed the shut-in test; check fittings and/or repeat using a new canister.
l. After the shut-in leak test is complete, begin sample collection immediately, or close the valve on the canister until sample collection begins (e.g., during inert gas tracer testing).

D.4 Leak Test to Verify Air Tightness of Sample Collection Point – Semi-Quantitative Tracer

Leak testing to verify the integrity of the sample collection point is required. This section describes a semi-quantitative inert gas tracer test, which is one of the options recommended to meet this objective. Common semi-quantitative tracers include 1,1-difluoroethane [commercially available as electronic dusting spray] and isopropyl alcohol [commercially available as rubbing alcohol].

Field Procedures

a. Complete shut-in leak test or equivalent to verify the air-tightness of the sample collection train as described in Section D.3 above.
b. Apply tracer using one of the following methods. Note that the application method is project/site geology dependent, and should be selected on a project-by-project basis. When using the container method (described below), surface concentrations of the tracer are very high, and even a small (<1%) leak may result in a large peak in the VOC analysis. This could result in cross contamination of equipment during analysis or unnecessary sample

dilution (elevated reporting limits). However, using the rag method, the tracer is not persistent over time. Therefore use of the container method may be more appropriate when the sample collection time exceeds 10 minutes.

- Rag Method
  i. Place rag in a clean resealable bag (e.g., Ziploc). Apply tracer to the rag by spraying 1,1-difluoroethane (electronic dusting spray, verify composition prior to use) to fill the inside the bag or if using isopropyl alcohol, pour a small volume of tracer onto the rag (<10 mL).

  ii. Seal the bag and agitate for a few seconds to allow the tracer to be fully absorbed into the rag.

  iii. Place the rag around the sampling apparatus. Rag can be dumped from the bag onto the ground next to the sampling point to limit contact with the saturated rag and minimize the potential for contamination of sampling equipment with the tracer (Photograph 19).

  Note that tracer may be reapplied to the same rag at each sampling point. However use extreme care when handling tracer-soaked rag and bag to minimize the potential from false positives due to contamination of sampling equipment. Contain rag in an air-tight bag between uses to prevent volatilization into field vehicle. Change gloves immediately after handling rag. Never touch sampling equipment with gloves that could be contaminated with tracer.

- Container Method
  i. To the extent feasible, prepare the surface around the sample point so that a seal between the surface and the containment device can be formed. For example, wipe down the floor with a wet paper towel in the vicinity of the sampling location and allow the floor to dry.

  ii. Use a clear plastic bag to contain the sample collection apparatus and sample collection point. Note a new plastic bag should be used for each sample to reduce the likelihood for residual tracer contamination of the sampling assembly and potential false positives.

  iii. If using 1,1-difluorethane as the tracer skip to Step iv below. If using isopropyl alcohol, wet a small section of paper towel (<10 mL) and place the wetted paper towel inside the bag. Be sure the towel is placed next to, not in direct contact with, the sampling apparatus.

  iv. Close and seal containment apparatus. Use duct tape and/or weights to form the best seal possible for the surface around the sample collection point (Photograph 20).

  v. If using isopropyl alcohol as the tracer, skip this step. Spray 1,1-difluorethane (electronic dusting spray, verify composition prior to use) into the inside of the containment apparatus through a small hole in the plastic bag. Be sure that spray is directed into the plastic bag and not onto the sample collection train itself.

c. Immediately proceed with sample collection as described in Section 2.2.5 of the SOP.

d. Verify that analysis of the tracer is included in the analyte list.

Data Evaluation
The concentration of the leak test tracer compound is determined by the analytical laboratory with other concentration data. Detection of the leak test compound does not automatically indicate that a significant leak occurred. Vapor intrusion guidance for many states provides thresholds for acceptable leaks. If applicable regulatory guidance does not specify otherwise, a leak threshold of 10-percent is typically recommended. Expected surface air concentrations of common tracers (both 1,1-difluorethane and isopropyl alcohol) based on application method are listed below:

Application Method	Approximate Surface Concentration	Target Tracer Concentration*
Rag Method	1,000,000 ug/m^3	<100,000 ug/m^3
Container Method	1,000,000,000 ug/m^3	<100,000,000 ug/m^3

*Tabulated target tracer concentration is based on an acceptable leak threshold of 10-percent. The actual target tracer concentration may vary based on applicable regulatory guidance.
Source: H&P Mobile Geochemistry, 2013. *Evaluation of Leak Check Procedures for Soil Vapor Sampling*.

Using these approximate surface concentrations as a guide, concentrations which exceed the project-specific leak threshold, indicate that sample data are suspect, and the Project Manager should be contacted to determine appropriate corrective action, e.g., data qualification, resampling, repair/replacement of the sample collection point, etc.

D.5 Leak Test to Verify Air Tightness of Sampling Point – Quantitative Tracer

Leak testing to verify the integrity of the sample collection point is required. This section describes a quantitative inert gas tracer test, which is one of the options recommended to meet this objective.

a. Use an air flow rate meter (Dry Cal® or equivalent) to determine the flow rate of the inert gas detector.
   i. Using tubing, connect the inert gas detector probe to the outlet of the flow rate meter. The type of tubing used here is optional; the only requirement is that there is a good fit in order to obtain an accurate flow rate reading. Record the flow rate of the inert gas detector (mL/min).

b. Calibrate the inert gas detector according to the manufacturer's recommendations.
c. If used, install a T-connection. The T-connection, such as that shown in Photograph 17, connects the sample point to both the inert gas detector (which may also be used to double as the purge pump) and the sampling canister, allowing flow from the sample point to be switched from the inert gas detector to the sampling canister without the introduction of ambient air. In order to assemble a stainless-steel T-connector with the parts listed in Section D.2, follow the procedures below:
   i. Cut a 1-foot long section of disposable tubing and attach to the down-flow side of the ball valve. Lock the tubing by closing the $^1/_4$-inch nut to be finger-tight, then

turn the nut with a wrench approximately 45 degrees in a clockwise direction. Check to ensure that the tubing is firmly attached to the ball valve.

ii. If not already attached, attach nuts with ferrules to each side of the $^{1}/_{4}$-inch tee. Install a $^{1}/_{4}$-inch OD port connector between the tee and the ball valve. Tighten both nuts approximately 45 degrees in a clockwise direction to lock the tee and the ball valve together.

iii. Install one nut and a port connector to the base of the tee. The connection between the connector and the tee will need a ferrule, but the connection between the connector and the sampling canister will not.

iv. Components can be field screened for leaks by placing the assembly into water and passing air through the components.

v. At the time of sampling, attach the sample tubing to the one remaining open port in the tee. Lock the tubing by closing the $^{1}/_{4}$-inch nut to be finger-tight, then turning the nut with a wrench approximately 45 degrees in a clockwise direction.

vi. At the time of sampling, connect the base of the tee with the port connector to the top of the sample collection train.

vii. Install the inert gas containment system using either the plastic wrap method or inverted container method as described below:

D.5.1 Plastic Wrap Method (for smooth interior surfaces only)

a. Wipe down floor with a wet paper towel in the vicinity of the sampling location to ensure a good seal and allow the floor to dry.

b. Allocate an approximately 2-foot by 2-foot section of plastic wrap and push the sample tubing through the center of the plastic wrap. The plastic wrap should form tightly to the tubing.

c. Connect the sample collection train with Teflon® or Teflon®-lined tubing to the vapor point as described in Section 2.2.5 of the SOP.

d. Slide the plastic wrap down the tubing until it reaches the floor.

e. Place the polyethylene tubing from the inert gas source under the plastic wrap. Attach the plastic wrap to the floor with duct tape or equivalent. If necessary, use a small piece of duct tape to secure the plastic wrap seal around the sample tubing. See Photograph 21 for an example layout.

The edges of the plastic and any penetrations through the plastic should be checked with the tracer gas detector for leaks. If any leaks are found, the leaks need to be sealed prior to purging and sampling.

D.5.2 Inverted Container Method

a. Obtain a plastic container, plastic tote, or similar container large enough to cover the sampling point (Photograph 22). If tracer testing of the entire sampling apparatus is desired, the container should be large enough to fit the entire sampling apparatus (including canister) inside (Photograph 23).

b. Modify the container for tracer testing by drilling three holes in the lower end of the container, sized appropriately for commonly sized tubing:

- One hole for the inert gas supply to enter the container (using larger diameter drill bit so tubing can fit through hole):
- One hole for the sample tubing to exit the container (using larger diameter drill bit so tubing can fit through hole):

- One hole to allow the tracer gas meter to quantify the concentration in the atmosphere of the shroud (using smaller diameter drill bit).

Note a larger container may be used such that the sample canister and sample collection train is contained within the container. If so, tracer testing will also detect leaks and short-circuiting from the sample collection apparatus, not just the sample collection point.

c. Wipe down floor with a wet paper towel in the vicinity of the sampling location to ensure a good seal and allow the floor to dry.
d. Attach sample collection train to the vapor point as described in Section 2.2.5 of the SOP. If a small container is used, run the sample tubing through the container.
e. Place the container over the sample point. Wet bentonite paste, weather-stripping, or duct tape may be installed around the rim of the container to help limit air flow and ensure a stable helium-enriched environment around the sample collection point.
f. Set up an inert gas tank and regulator to add the gas to the enclosure.
g. Connect the tubing from the inert gas tank to the container by inserting the tubing through the hole in the lower end of the container.
h. Introduce inert gas into the containment system and record concentration in the shroud. Open the ball valve and purge one tubing volume and begin measuring inert gas concentrations until three purge volumes have been removed. If the tracer concentration detected in the sample tubing is less than or equal to 10 percent (unless a different project-specific value applies) of the concentration of the inert gas in the shroud, the seal is considered competent. If the inert gas is detected in the sample tubing above 10 percent relative to the concentration in the shroud, then the seal around the sampling point is not competent and additional bentonite must be installed prior to sampling. Repeat the leak check procedure until less than or equal to 10 percent of the inert gas is detected. Record the final inert gas concentration in the field book or on a field form. Purging three to five purge volumes while collecting inert gas readings prior to sample collection is ideal.
i. Use the ball valve on the T-connector to redirect flow from the inert gas detector to the sampling canister, or if a T-connector is not used, remove the sample tubing from the inert gas detector and immediately connect the sample collection apparatus. Cover the end of the tubing when changing the tubing over so ambient air does not enter the sample tubing.
j. Complete shut-in leak test described in Section D.3 above if the sample collection train was not enclosed in the tracer containment apparatus (e.g., inverted container) during quantitative tracer testing. Otherwise, proceed with sample collection as described in Section 2.2.5 of the SOP.

Standard Operating Procedure Installation and Extraction of the Vapor Pin®

Updated September 9, 2016

Scope:

This standard operating procedure describes the installation and extraction of the VAPOR PIN® for use in sub-slab soil-gas sampling.

Purpose:

The purpose of this procedure is to assure good quality control in field operations and uniformity between field personnel in the use of the VAPOR PIN® for the collection of sub-slab soil-gas samples or pressure readings.

Equipment Needed:

- Assembled VAPOR PIN® [VAPOR PIN® and silicone sleeve(Figure 1)]; Because of sharp edges, gloves are recommended for sleeve installation;
- Hammer drill;
- 5/8-inch (16mm) diameter hammer bit (hole **must** be 5/8-inch (16mm) diameter to ensure seal. It is recommended that you use the drill guide). (Hilti™ TE-YX 5/8" x 22" (400 mm) #00206514 or equivalent);
- 1½-inch (38mm) diameter hammer bit (Hilti™ TE-YX 1½" x 23" #00293032 or equivalent) for flush mount applications;
- ¾-inch (19mm) diameter bottle brush;
- Wet/Dry vacuum with HEPA filter (optional);
- VAPOR PIN® installation/extraction tool;
- Dead blow hammer;
- VAPOR PIN® flush mount cover, if desired;
- VAPOR PIN® drilling guide, if desired;
- VAPOR PIN® protective cap; and
- VOC-free hole patching material (hydraulic cement) and putty knife or trowel for repairing the hole following the extraction of the VAPOR PIN®.

Figure 1. Assembled VAPOR PIN®

Installation Procedure:

1) Check for buried obstacles (pipes, electrical lines, etc.) prior to proceeding.

2) Set up wet/dry vacuum to collect drill cuttings.

3) If a flush mount installation is required, drill a 1½-inch (38mm) diameter hole at least 1¾-inches (45mm) into the slab. Use of a VAPOR PIN® drilling guide is recommended.

4) Drill a 5/8-inch (16mm) diameter hole through the slab and approximately 1-inch (25mm) into the underlying soil to form a void. Hole **must** be 5/8-inch (16mm) in diameter to ensure seal. It is recommended that you use the drill guide.

VAPOR PIN® protected under US Patent # 8,220,347 B2, US 9,291,531 B2 and other patents pending

5) Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.

6) Place the lower end of VAPOR PIN® assembly into the drilled hole. Place the small hole located in the handle of the installation/extraction tool over the vapor pin to protect the barb fitting, and tap the vapor pin into place using a dead blow hammer (Figure 2). Make sure the installation/extraction tool is aligned parallel to the vapor pin to avoid damaging the barb fitting.

Figure 2. Installing the VAPOR PIN®

During installation, the silicone sleeve will form a slight bulge between the slab and the VAPOR PIN® shoulder. Place the protective cap on VAPOR PIN® to prevent vapor loss prior to sampling (Figure 3).

Figure 3. Installed VAPOR PIN®

7) For flush mount installations, cover the vapor pin with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover (Figure 4).

Figure 4. Secure Cover Installed

8) Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil-gas conditions to re-equilibrate prior to sampling.

9) Remove protective cap and connect sample tubing to the barb fitting of the VAPOR PIN®. This connection can be made using a short piece of Tygon™ tubing to join the VAPOR PIN® with the Nylaflow tubing (Figure 5). Put the

Nylaflow tubing as close to the VAPOR PIN® as possible to minimize contact between soil gas and Tygon™ tubing.

Figure 5. VAPOR PIN® sample connection

10) Conduct leak tests in accordance with applicable guidance. If the method of leak testing is not specified, an alternative can be the use of a water dam and vacuum pump, as described in SOP Leak Testing the VAPOR PIN® via Mechanical Means (Figure 6). For flush-mount installations, distilled water can be poured directly into the 1 1/2 inch (38mm) hole.

Figure 6. Water dam used for leak detection

11) Collect sub-slab soil gas sample or pressure reading. When finished, replace the protective cap and flush mount cover until the next event. If the sampling is complete, extract the VAPOR PIN®.

<u>Extraction Procedure:</u>

1) Remove the protective cap, and thread the installation/extraction tool onto the barrel of the VAPOR PIN® (Figure 7). Turn the tool clockwise continuously, don't stop turning, the VAPOR PIN® will feed into the bottom of the installation/extraction tool and will extract from the hole like a wine cork, DO NOT PULL.

2) Fill the void with hydraulic cement and smooth with a trowel or putty knife.

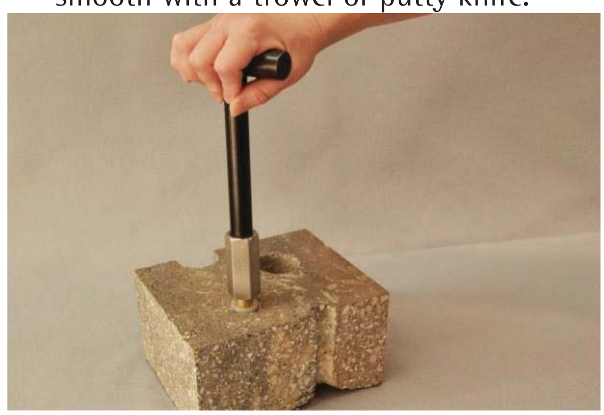


Figure 7. Removing the VAPOR PIN®

- Prior to reuse, remove the silicone sleeve and protective cap and discard. Decontaminate the VAPOR PIN® in a hot water and Alconox® wash, then heat in an oven to a temperature of 265° F (130° C) for 15 to 30 minutes. For both steps, **STAINLESS – ½ hour, BRASS 8 minutes**

3) Replacement parts and supplies are available online.

Standard Operating Procedure
Leak Testing the VAPOR PIN®
Via Water Dam

Updated March 28, 2016

Scope:

The operating procedure describes the methodology to test a VAPOR PIN® or equivalent sub-slab sampling device for leakage of indoor air.

Purpose:

The purpose of this procedure is to assess the potential for indoor air to leak past the VAPOR PIN ® and dilute the sub-slab soil gas sample.

Equipment Needed:

- VAPOR PIN® water dam
- Play-Doh or VOC free modeling clay
- distilled water
- VAPOR PIN® and associated sample tubing.

Procedure:

1) Drill a 5/8" diameter hole in the concrete slab and install the VAPOR PIN® as per the Standard Operating Procedure (SOP).

2) Clean the slab within a 2-inch radius of the VAPOR PIN® to remove dust. Avoid wetting the concrete or wait until the concrete is dry before proceeding and avoid cleaning with VOC-containing substances. A whisk broom or shop vacuum is recommended. Any remaining dust can be picked up with a piece of scrap Play-Doh or modeling clay.

3) Roll a 1-inch diameter ball of Play-Doh or modeling clay between your palms to form a "snake" approximately 7 inches long and press it against the end of the pipe couple. Push the couple against the slab to form a seal between the pipe and the concrete.

4) Attach the sample tubing to the top of the VAPOR PIN® and pour enough distilled water into the pipe couple to immerse base of the VAPOR PIN®, and if desired, the tubing connection at the top of the VAPOR PIN®.

5) Purge the sample point as required by the data quality objectives. Concrete will absorb some of the water, which is normal; however, if water is lost to the sub-slab, stop, remove the water from the couple, and reposition the VAPOR PIN® to stop the leakage. Reseat the leak test equipment, if needed.

6) If the VAPOR PIN® is installed in the flush-mount configuration, the larger hole can be filled with water in place of the plastic pipe fitting and Play-Doh or modeling clay.

Appendix B
Field Note Forms

TRC

PROJECT NAME: WisDOT - Northwoods Laundry Vapor Investigation

PROJECT NUMBER: ____________________

PROJECT MANAGER: ____________________

SITE LOCATION: Town of Minocqua, WI

DATES OF FIELDWORK: ____________________

PURPOSE OF FIELDWORK: Residential/Small Commercial Vapor Intrusion Monitoring

WORK PERFORMED BY: ____________________

SIGNED ____________________ DATE

CHECKED BY ____________________ DATE

TRC

GENERAL NOTES

PROJECT NAME:	WisDOT - Northwoods Laundry Vapor Investigation	DATE:	TIME ARRIVED:
PROJECT NUMBER:		AUTHOR:	TIME LEFT:

WEATHER		
TEMPERATURE: _______ °F	WIND: _______ MPH	VISIBILITY: _______

WORK / SAMPLING PERFORMED

PROBLEMS ENCOUNTERED	CORRECTIVE ACTION TAKEN

COMMUNICATION

NAME	REPRESENTING	SUBJECT / COMMENTS

SIGNED _______ DATE _______ CHECKED BY _______ DATE _______

TRC

PID FIELD CALIBRATION LOG

PROJECT NAME:	WisDOT - Northwoods Laundry Vapor Investigation	MODEL:	
PROJECT NUMBER.:		LAMP VOLTAGE:	
SAMPLER NAME:	0	SERIAL NO.:	

PID CALIBRATION CHECK

	DATE: TIME: INITIALS:	DATE: TIME: INITIALS:	DATE: TIME: INITIALS:	DATE: TIME: INITIALS:	DATE: TIME: INITIALS:
BATTERY CHECK	☐	☐	☐	☐	☐
ZERO GAS	/	/	/	/	/
SPAN GAS	/	/	/	/	/
AUDIBLE FAN MOTOR CHECK	☐	☐	☐	☐	☐
RESPONSE CHECK	☐	☐	☐	☐	☐

NOTES

PROBLEMS ENCOUNTERED	CORRECTIVE ACTION

SIGNED _______________ DATE

CHECKED _______________ DATE

REVISED 03/2008

AIR / VAPOR SAMPLE LOG

PROJECT NAME:	WisDOT - Northwoods Laundry Vapor Investigation	PREPARED	CHECKED
PROJECT NUMBER:		BY: DATE:	BY: DATE:

SAMPLE INFORMATION				
SAMPLE TYPE:	☐ COMPOSITE ☐ GRAB		**SAMPLE ID:**	
SAMPLE MEDIA	☐ INDOOR AIR ☐ SOIL VAPOR ☐ SYSTEM PERFORMANCE ☐ OTHER		LOCATION:	LOCATION COORDINATES: N: E:
SAMPLE DURATION:			SAMPLE HEIGHT / (DEPTH): N/A	
SAMPLE CONTAINER TYPE:	☑ SUMMA CANISTER	☐ TEDLAR BAG	☐ OTHER:	
FLOW VALVE ID / SERIAL NUMBER:			CANISTER SERIAL NUMBER:	

READING	TIME	VACUUM (INCHES - Hg / PSIG)	DATE	INITIALS	COMMENTS
INITIAL VACUUM CHECK					
INITIAL FIELD VACUUM					
FINAL FIELD VACUUM					

SAMPLE START TIME:	SAMPLE STOP TIME:

NOTES AND OBSERVATIONS

MOTORIZED VEHICLE STORAGE :

MOTORIZED VEHICLE TRAFFIC:

OPERATIONS (e.g., painting, oil recovery):

CLEANERS / SOLVENTS IN USE:

MATERIAL STORAGE (e.g., paint, gasoline):

NOTICEABLE ODORS:

AUDIBLE OR NEARBY HVAC OPERATION:

OTHER:

ADDITIONAL COMMENTS:

Purge: 1 - Well Volume Start: ________ Stop:___________ Remaining Well Volumes Restart: _________ Stop:__________ Total Purge Time:_____________

Total Well Volumes Removed Before Sampling: _____________

Helium Test: Background ________________________ Shroud ______________________________ Soil Gas ____________________________

Shut-in Test: Initial Vacuum________________ Initial Time_____________ Final Vacuum_________________ Final Time_________________

SHIPPING METHOD: ____________________	DATE SHIPPED: ____________________	AIRBILL NUMBER: ____________________
COC NUMBER: ____________________	SIGNATURE: ____________________	DATE SIGNED: ____________________

Appendix C
WI Vapor Quick Look-Up Table

WI Vapor Quick Look-Up Table [1, 2]
Indoor Air Vapor Action Levels and Vapor Risk Screening Levels
Based on **November 2017** U.S.EPA Regional Screening Levels

CHEMICAL	RESIDENTIAL AF = 0.03 INDOOR AIR VAL		RESIDENTIAL AF = 0.03 SUB-SLAB VAPOR VRSL		SMALL COMMERICAL AF = 0.03 INDOOR AIR VAL		SMALL COMMERICAL AF = 0.03 SUB-SLAB VAPOR VRSL		LARGE COMMERCIAL/INDUSTRIAL AF = 0.01 INDOOR AIR VAL		LARGE COMMERCIAL/INDUSTRIAL AF = 0.01 SUB-SLAB VAPOR VRSL		MOLECULAR WEIGHT	U.S.EPA RSL BASIS
	μg/m^3	ppbV	μg/m^3	ppbV	μg/m^3	ppbV	μg/m^3	ppbV	μg/m^3	ppbV	μg/m^3	ppbV	g/mole	
Benzene	3.6	1.1	120	37	16	4.9	530	160	16	4.9	1,600	490	78.11	c
Carbon Tetrachloride	4.7	0.73	160	24	20	3.1	670	100	20	3.1	2,000	310	153.82	c
Chloroform	1.2	0.24	40	8.0	5.3	1.1	180	37	5.3	1.1	530	110	119.38	c
Chloromethane	94	45	3,100	1,500	390	190	13,000	6,300	390	190	39,000	19,000	50.49	n
Dichlorodifluoromethane	100	20	3,300	670	440	88	15,000	2,900	440	88	44,000	8,800	120.91	n
1,1-Dichloroethane (1,1-DCA)	18	4.4	600	150	77	19	2,600	630	77	19	7,700	1,900	98.96	c
1,2-Dichloroethane (1,2-DCA)	1.1	0.27	37	9.0	4.7	1.1	160	37	4.7	1.1	470	110	98.96	c
1,1-Dichloroethylene (1,1-DCE)	210	52	7,000	1,700	880	220	29,000	7,300	880	220	88,000	22,000	96.94	n
1,2-Dichloroethylene (cis and trans)	--	--	--	--	--	--	--	--	--	--	--	--	96.94	--
Ethylbenzene	11	2.5	370	83	49	11	1,600	370	49	11	4,900	1,100	106.17	c
Methylene Chloride	630	180	21,000	6,000	2,600	740	87,000	25,000	2,600	740	260,000	74,000	84.93	n
Methyl Tert-Butyl Ether (MTBE)	110	30	3,700	1,000	470	130	16,000	4,300	470	130	47,000	13,000	88.15	c
Naphthalene	0.83	0.16	28	5.3	3.6	0.68	120	23	3.6	0.68	360	68	128.18	c
Tetrachloroethylene (PCE)	42	6.2	1,400	210	180	27	6,000	900	180	27	18,000	2,700	165.83	n
Toluene	5,200	1,400	170,000	47,000	22,000	5,700	730,000	190,000	22,000	5,700	2,200,000	570,000	92.14	n
1,1,1-Trichloroethane (1,1,1-TCA)	5,200	940	170,000	31,000	22,000	4,000	730,000	130,000	22,000	4,000	2,200,000	400,000	133.41	n
Trichloroethylene (TCE)	2.1	0.39	70	13	8.8	1.6	290	53	8.8	1.6	880	160	131.39	n
Trichlorofluromethane	--	--	--	--	--	--	--	--	--	--	--	--	137.37	--
1,2,4 -Trimethylbenzene	63	13	2,100	430	260	52	8,700	1,700	260	52	26,000	5,200	120.20	n
1,3,5- Trimethylbenzene	63	13	2,100	430	260	52	8,700	1,700	260	52	26,000	5,200	120.20	n
Vinyl Chloride	1.7	0.65	57	22	28	11	930	370	28	11	2,800	1,100	62.50	c
Xylene (mix)	100	23	3,300	770	440	100	15,000	3,300	440	100	44,000	10,000	106.17	n
Xylene (n,m,o separately)	100	23	3,300	770	440	100	15,000	3,300	440	100	44,000	10,000	106.17	n

Notes

All values reported to two significant digits.

-- = Inhalation toxicity values are *not* available from U.S. EPA

AF = Attenuation Factor

VAL = Vapor Action Level

VRSL = Vapor Risk Screening Level

U.S. EPA RSL = Regional Screening Level

n= noncancer; c = carcinogenic

Footnotes

1. Quick Look-up Table only includes common contaminants. To determine the VAL and VRSL for other contaminants, refer to the steps on the next page.
2. Concentrations reported in ppbv and μg/m^3 are *not* equivalent for air. If comparing datasets with both units, refer to the instructions on the next page for how to convert between ppbv and μg/m^3.

STEP 1: Check if the contaminant is sufficiently volatile and toxic to pose a vapor risk:

- Open the current U.S.EPA Vapor Intrusion Screening Levels (VISLs) calculator spreadsheet: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls
- Go to the worksheet titled "VISL"and scroll down to find the chemical name in the list.
- Scroll over to columns F and G to determine if the chemical is sufficiently volatile and toxic to pose an inhalation risk via vapor intrusion.
  - If no, this means the chemical does not pose an inhalation risk, and the vapor intrusion assessment may be complete for that chemical.
  - If yes, move to Step 2.

STEP 2: Determine the indoor air Vapor Action Level (VAL)

- On the worksheet titled "VISL", choose an Exposure Scenario from the dropdown menu:
  - Select Residential for settings meeting the definition of residential in Wisc. Admin. § NR 700.03(49g).
  - Select Commercial for settings meeting definition of commercial or industrial in Wisc. Admin. § NR 700.03(39m).
- Set Target Risk for Carcinogens to 1.00 E-05 and Target Hazard Quotient for Non-Carcinogens to 1.
- Lookup the Target Indoor Air Concentration for the chemical in column H.
- Target Indoor Air Concentration = **VAL.**

STEP 3: Calculate the Vapor Risk Screening Levels (VRSLs)

- Select the appropriate attenuation factor from table below:
  - Attenuation factor is based on the building type and the location where the sample was collected.
  - It is expected that the *sub-slab vapor attenuation factor* will be the default for most sampling scenarios.
- Divide each VAL by the selected attenuation factor.
- VAL/attenuation factor = **VRSL**.

MEDIA	ATTENUATION FACTOR	
	RESIDENTIAL OR SMALL COMMERCIAL BUILDING	INDUSTRIAL OR LARGE COMMERCIAL BUILDING
Crawl space	1	1
Sub-slab vapor	**0.03**	**0.01**
Deep soil gas	0.01	0.001
Groundwater*	0.001	0.0001

**** Groundwater VRSLs:***

- Use the following formula to calculate the groundwater concentrations that could cause a VAL exceedance in indoor air for a compound.
- *Do not use this formula for PCE and TCE***.** If PCE or TCE are in groundwater, use their respective Wis. Admin. Code ch. NR 140 Enforcement Standards as the vapor screening criteria.

$$C_{gw} = \frac{VAL}{H \times AF \times 1000\ ^{L}/_{m^3}}$$

Where:

C_{gw} = Groundwater Concentration (µg/L)

VAL = Vapor Action Level (µg/m^3)

AF = attenuation factor (dimensionless or unitless)

- Use *groundwater attenuation factor* in most cases, or
- Use the *sub-slab attenuation factor* if groundwater is near, or in contact with the building foundation.

H = Henry's Law constant (dimensionless)

- On the VISL spreadsheet, go to worksheet titled "Parameters Summary" and look up the Henry's law constant for the chemical.
- Or go to https://www3.epa.gov/ceampubl/learn2model/part-two/onsite/esthenry.html
  Input the temperature and chemical name to get Henry' law constant.

Convert data from ppbv to µg/m^3 (if needed)

- If a vapor dataset has multiple units (ppbv and µg/m^3), convert the data to a common unit of measure prior to evaluating trends or comparing values in the data.
- To convert between µg/m^3 and ppbv, go to http://www3.epa.gov/ceampubl/learn2model/part-two/onsite/ia_unit_conversion.html , or use following formula:

$$\mu g/m^3 = \frac{ppbv * MW}{24.05}$$

Where:

MW = molecular weight (g/mole)

24.05 = conversion factor based on temperature = 20°C and pressure = 1 atm