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May 19, 2017

Mr. Mark Drews
Wisconsin Department of Natural Resources
Remediation and Redevelopment Program
141 NW Barstow Street, Room 180
Waukesha, WI 53188

Subject: Supplemental Site Investigation Work Plan - Revision 2
Former Navistar Foundry Facility, Waukesha, Wisconsin
WDNR BRRTS Activity #02-68-098404, WDNR FID #268005430

Dear Mr. Drews:

On behalf of Navistar, Inc., please find attached the Supplemental Site Investigation Work Plan - Revision 2 (SSIWP) for additional investigative work at the above referenced facility. We have also provided a copy of the revised work plan in redline for your convenience. The SSIWP is considered a final document after TRC incorporated comments from the WDNR during a conference call on March 30, 2017, and Navistar and TRC sent WDNR comment responses and additional information on April 13 and April 14, 2017. Please note that additional revisions to the document have been made that reflect information received from other parties on areas of concern on the subject property. Navistar requests that the WDNR approve this document so that the field work can proceed.

The Vapor Intrusion Investigation Work Plan - Revision 1 has also been prepared for this project and is included as an Appendix to the SSIWP. The comments WDNR made on Revision 1 of the document have been addressed in this revision. It is our understanding that the WDNR will review the revised Vapor Intrusion Investigation Work Plan and approve the document. Thank you for your time and consideration of this request.

If you have any questions or would like to discuss further, please feel free to call or email me (608-826-3666 or jwedekind@trcsolutions.com).

Sincerely,

TRC Environmental Corporation

James Wedekind, P.G.
Senior Hydrogeologist

Enclosure: Supplemental Site Investigation Work Plan - Revision 2 (hard copy)

cc: Mr. Ferdinand Alido, Navistar (pdf via email)
Mr. Chris Perzan, Navistar (pdf via email)
Mr. Jack Shih, Navistar (pdf via email)
Mr. Brian Harms, TRC (pdf via email)
Mr. Dave Seitz, TRC (pdf via email)

# Supplemental Site Investigation Work Plan
# Revision 2

## Former Navistar Foundry Facility
## 1401 Perkins Avenue
## Waukesha, Wisconsin

*BRRTS #02-68-098404*

May 2017

*Prepared For*
*Navistar, Inc.*
*Lisle, Illinois*


Brian Harms
Project Manager

James E. Wedekind, P.G.
Senior Hydrogeologist

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# Section 1
# Introduction

## 1.1 Background

The former Navistar facility (site) is located at 1401 Perkins Avenue in Waukesha, Wisconsin (Figure 1). Navistar, Inc. (Navistar) has requested assistance with case closure for Wisconsin Department of Natural Resources (WDNR) Case Activity Number: 02-68-098404. The site remains active and the facility is currently operated by Renaissance Manufacturing Group (RMG) – Waukesha Foundry. RMG also owns the operations at the facility. However, Navistar remains the current property owner. The initial investigation into this release occurred in the late 1980s and has gone through numerous investigations and regulatory reviews. Navistar completed a site investigation at the site in 2014 and issued a Site Investigation report dated August 2015. WDNR responded in a letter from the WDNR dated June 29, 2016, requesting additional information. In summary, the WDNR letter requested the following:

1. Provide the WDNR with historical records that summarized the types, quantities, and disposal of wastes generated at the facility including any Phase 1 and Phase 2 environmental site assessments, data on chlorinated solvents in the soil and groundwater. Navistar provided that information on compact discs dated August 25, 2016.
2. Provide additional information to dispute that Navistar is responsible for "the chlorinated solvent plume west of the facility."
3. Continue sampling groundwater on a quarterly basis to determine the stability of the contaminant plume. In addition, sample the adjacent HOBO Spring and Unnamed Creek in Frame Park
4. Define the horizontal and vertical extents of groundwater contamination and complete a vapor intrusion assessment on- and off-site.
5. Provide a Site Investigation Work Plan that includes the comments in the June 2016 letter within 60 days.
6. Provide a Site Investigation Report after completion of the investigation.
7. Provide a Remedial Action Options Report.

Navistar, TRC, and the WDNR met on August 23, 2016, in Waukesha to discuss the findings of the report and the path forward for the project. Item #2 was discussed and Navistar reiterated that the additional investigation only confirmed that the former Wisconsin Coach Lines is a likely source of the groundwater contamination and several other adjacent properties (e.g. McGlenn property, Slater property, and Alloy Products Corp., etc.) are known sources of chlorinated volatile organic compounds (CVOCs) and likely contribute the CVOC plume. Navistar voiced concern that those contaminated properties were prematurely closed by WDNR resulting in a missed opportunity to determine their impact as potential sources.

WDNR stated that Navistar should focus on further delineation of the CVOC plume and "follow the plume upgradient" and investigate former solvent use areas within the facility to demonstrate with greater certainty that the former Navistar casting facility was not the source of the CVOC plume. WDNR added that their primary concern is that the CVOC plume may pose a risk of vapor intrusion into nearby buildings. Navistar reiterated that the solvent use areas were investigated in the past, but offered to investigate these concerns with additional subsurface investigation as presented in this work plan. TRC prepared Revision 0 of the work plan to address items #2 through #6 of the WDNR June 2016 letter. The work plan was submitted and received by WDNR with the appropriate review fee on October 3, 2016 and comments to the work plan were supplied by WDNR by letter dated November 9, 2016. Revision 1 to the work plan followed after a telephone conversation to discuss the comments between Mr. Mark Drews of WDNR and James Wedekind of TRC. A draft version of Revision 1 was submitted to the WDNR via email dated December 2, 2016. WDNR comments on the draft were discussed in a conference call between WDNR, Navistar, and TRC on December 14, 2016. In that meeting, it was decided that a vapor intrusion work plan would be included as an attachment to the work plan in a revision submitted in January 2017.

WDNR disapproved Revision 1 via letter dated March 15, 2017 citing the current investigation did not "appropriately address the requirement to fully scope the Site Investigation as required in NR 716.07(1)". In that letter WDNR requested that Navistar:

1. Include a description of "all of the potential source areas beneath and within the Navistar building and property areas have been (sic) or will be evaluated".
2. Provide information from a former lawsuit including: "Former and current Phase 1 reports completed for the property", specific Interrogatory Responses from that case, and any additional information related to the former Refuse Pit.
3. Address two specific comments relating to the vapor intrusion investigation, and
4. Comply with four general requirements of NR 700 investigations.

Navistar and WDNR discussed these comments via a conference call on March 30, 2017 and Navistar submitted comment responses regarding the lawsuit via letter dated April 13, 2017. TRC submitted specific comment responses to WDNR via email dated April 14, 2017.

This Revision 2 of the Supplemental Site Investigation work plan (SSI work plan or work plan) was prepared to include changes made to Revision 1 based on comments received from WDNR and additional potential source area information obtained since submittal of Revision 1. This information includes documents obtained from third parties such as additional maps related to the Refuse Pit (already provided to WDNR) and the DRAFT Phase I Environmental Site Assessment (ESA) for Renaissance Manufacturing Group performed by PM Environmental[1] (2014).

As required under NR 700, field work as described in this SSI work plan will commence within 60 days of approval of the work plan. Upon completion of the field work and receipt of the laboratory data, a Supplemental Site Investigation Report will be prepared and submitted to WDNR within 60 days. Preparation of a Remedial Action Options Report will be completed within 60 days of completion of the site investigation report. A complete project schedule is provided in Section 5 of this work plan.

## 1.2 Purpose and Scope

The purpose of this work plan is to provide details of field work, laboratory analysis, and reporting to investigate areas of concern identified at the site and determine the horizontal extent of groundwater containing CVOCs. Navistar will also install deeper, bedrock monitoring wells to assess the vertical extent of CVOCs. The extent of CVOCs in groundwater will also serve as an initial step to complete a vapor intrusion assessment of the Navistar facility and the surrounding properties. The vapor intrusion investigation will proceed under a separate work plan that is attached to this document (Appendix B).

On behalf of Navistar, TRC has prepared this work plan to complete the following tasks:

- Advance 25 borings and collect subsurface soil samples using direct push techniques at 19 areas of concern identified within the former Navistar facility. Temporary monitoring wells will be installed and sampled in 10 of those borings.
- Sample sediment from seven (7) floor drains and 20 catch basins identified within the facility.
- Install, develop, and sample 16 new groundwater monitoring wells (13 water table and three in deeper bedrock) to determine the extent of chlorinated volatile organic compounds (CVOCs) in groundwater,
- Collect groundwater samples at all (16 new and 12 existing) site monitoring wells on a quarterly basis until all wells have been sampled at least eight (8) times.
- Prepare a Site Investigation Report that summarizes the results of activities presented in this work plan.

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1 While Navistar has obtained RMG's permission to provide this Phase I ESA study to WDNR, Navistar requests that WDNR treat this document as confidential business information developed in the context of a private transaction.

The Site Investigation will be conducted in two phases, with the initial phase consisting of the subsurface sampling using direct push borings and temporary wells, followed by a second phase that includes monitoring well installation. The purpose of the phased approach is to provide data in the initial investigation to make informed decisions on the placement of permanent monitoring wells within the facility.

# Section 2
# Site Conditions

A site summary, site geology and hydrogeology, summarized history of previously completed investigations for the site, and areas of concern (AOCs) are summarized below.

## 2.1 Site Summary

### 2.1.1 Site Location

The approximately 14-acre site is located at 1401 Perkins Ave. in the City of Waukesha, Waukesha County, Wisconsin (SE ¼, SW ¼, Section 35, Township 7 North, Range 19 East).

### 2.1.2 Site Description

The former Navistar facility (site) is located within the City of Waukesha and bordered on the west by Whiterock Avenue and on the east by Cleveland Avenue. The boundary to the south is Perkins Avenue. The site is bordered to the north by the former WCL site (BRRTS #0368004354), the Dairyland Buses site (BRRTS #0368001343), and Niagara Street. Those contaminated properties are now occupied by Interstate Pump and Tank (IPT) (Figure 2). An extensive amount of environmental sampling has occurred on these sites and Navistar in the past, with at least 55 soil borings and 32 monitoring wells installed with multiple soil and groundwater samples analyzed at most locations. A portion of the Navistar property, west of the former WCL building, was leased by WCL from Navistar for use in their bus transportation operations. The McGlenn property that includes the Tews Company (Former General Castings – BRRTS #0368004657), TBA Distributors (BRRTS #036800424), and the Former Roundhouse Site (BRRTS #0268168232) is located to the south/southwest of the Navistar property, south of Perkins Avenue.

Land use surrounding the Navistar facility is a mixture of residential, commercial, and industrial. The site property is zoned M-1 and M-2 for Light and General Manufacturing. The surface topography of the area is relatively flat and slopes toward the Fox River which is located approximately 600 feet west of the facility. In addition, an unnamed creek enters a culvert near the east side of Navistar's facility and discharges to the west into the Fox River (RMT, 1999). There are several more contaminated facilities located within the drainage area of this unnamed creek other than those listed above.

### 2.1.3 Facility Operations

The site is an active iron foundry and metals manufacturing facility that consists of 30, single-story industrial buildings covering over 222,500 square feet. Foundry operations have occurred at the site since 1891. International Harvester purchased the property from General Malleable Corporation in 1946 and operated as a malleable iron castings foundry. In 1986, International Harvester changed its name to Navistar, Inc. Navistar operated the foundry under various names until May 2015 when the facility (exclusive of real estate) was sold to Renaissance Manufacturing Group (RMG).

### 2.1.4 Areas of Concern

Navistar has reviewed historical documents in the course of preparation of this Work Plan and taken those into account in its design as indicated and discussed during the August 23, 2016 meeting with WDNR. Navistar has identified 19 AOCs. Identification of these areas are based on site records and current practices and summarized as recognized environmental conditions in the Phase I ESA (PM Environmental 2014). There is no evidence of a release from any of these areas, other than one of the USTs. The following AOCs are illustrated on Figure 2 and are identified for further investigation:

1. **Soil at NMW-3R** – CVOCs were detected in subsurface soil in the vicinity of this monitoring well near the West Substation. The extent of the soil impacts has not been fully delineated.
2. **Foundry Fill** – Foundry sand with has been identified as general fill material in several borings at the site. Foundry sand may include elevated concentrations of metals and polyaromatic hydrocarbons (PAHs). Spent foundry sand was the primary material disposed in the Refuse Pit.
3. **Building 29 – Core Room –** Core wash activity has been conducted at this location since the building was constructed in 1973. The core wash process used solvents containing less than 5 per cent 1,1,1-trichloroethane (TCA). Core oil was stored in a 6,000 gallon UST located outside the building and drummed solvents were stored in the adjacent West Yard. Activities in Building 29 have included petroleum-based liquid parting and release agents that include 1,1,1-TCA in addition to the core wash solution.
4. **Buildings 7 / 7A –** Building 7 was built in 1930 and Building 7A dates back to 1891. Historic uses include core wash, service and repair operations, and evidence of subgrade pits. These buildings currently house the pouring lines and melting furnaces. With most of the "hot work" at the foundry done in these buildings, they are basically inaccessible for investigative work. Although borings and monitoring wells have been placed in the alley located north of the building (Harrison Avenue).

5. **Building 7B –** Building 7B is one of the older structures at the facility as it was completed in 1896. Building 7B has been used for molding for many years and has included subgrade pits and liquid parting processes. The Refuse Pit is located immediately south of Building 7B.

6. **Building 7E /1 –** Building 7E was constructed in 1980. Building 1 is a series of small buildings (sections) built between 1946 and 1961 located immediately south of Building 7E. Building 7E was once used for core wash and was later called the Ford area, but is currently idle. Building 7E once housed a parts washer and liquid parting operations. Building 1 once housed a parts cleaning operation and also served as a locker room. Paved areas in Building 7E suggest that former subgrade equipment pits were once located within the building.

7. **Buildings 20 / 22 –** These buildings are located at the east end of Building 7E. Building 20 was built in 1930 and was once used for metal patterns manufacturing and is currently a storage room. Building 22 dates to 1954 and once served as the core room and a machine shop but currently is used for storage. A 500 gallon kerosene UST was removed from Building 20 in 1987.

8. **Building 4 –** Building 4 was built in 1979 and is currently referred to as the mill room but has multiple uses. The primary activities in the building are annealing, painting, and metal patterns fabrication, but it also includes a machine shop and service/maintenance shop and once housed an oil room. The maintenance area once housed a 30 gallon solvent tank that stored mineral spirits.

9. **Buildings 3 /15 / 16 –** Building 3 also serves many functions including shipping, patterns manufacture, and annealing. The building also includes a machine shop and hoisting equipment. Building 3 was built in 1902 and once included painting operations and a parts washer that included a 60 gallon holding tank for mineral spirits. Building 15 includes a repair shop and Building 16 dates to 1902 and once included a pattern shop.

10. **Buildings 17 / 25 –** Building 17 was built in 1930 and is used for vehicle maintenance and Building 25 was added in 1961 and is used for pattern production and was once used for shipping. Building 17 once included a machine shop and parts washer that both stored mineral spirits. A subgrade pit in Building 17 currently stores oil.

11. **Building 30 –** Building 30 dates to 1970 and is also referred to as the Gartland Foundry. Sheet metal was produced there at that time. The building includes a machine shop.

12. **Salvage Yard / HAZMAT area –** The area behind Building 31 was reportedly operated as an unpaved salvage yard from ca. 1962 until 1988. There are no records of what was stored in the yard. Two USTs in this area were found to be leaking

during removal operations in 1990. The sites were closed in 1995 and no further action was required. The HAZMAT pad stores hazardous and non-hazardous wastes beneath a covered area. A 1,000 gallon AST containing both gasoline and diesel fuel is currently located (and operational) in this area.

13. **Remaining Underground Storage Tanks (USTs)** – The historical record suggests that 15 USTs operated at various times at the facility. The USTs all stored petroleum products, typically fuel oil, diesel fuel, or gasoline. Most USTs were removed by 1990, however two, 20,000 gallon #6 fuel oil USTs were closed in place because they were located beneath the East Substation.

14. **Central Alleyway –** A railway once entered the facility from the west with a spur that ran between the main buildings, separating Building 7 and buildings 3 and 4. Spills and leaks of materials from the rail cars could have occurred in the Central Alleyway. The alley also included several heating oil ASTs. A 1,000 gallon gasoline UST was removed from the alley in 1990.

15. **East (Cleveland) Yard –** The East Yard was used as an above-ground storage area for petroleum distillates used as a liquid parting solvent stored in four, 250-gallon totes. The yard also included two, 1,000 gallon USTs containing gasoline and diesel fuel. The yard also contained two, 100 gallon ASTs for waste oil storage and a 2,600 gallon AST for waste coolant. The East Yard is still in use to store various metal items.

16. **West (Whiterock/Niagara) Yard –** The southern West Yard (Whiterock Yard) was used to store drums of core wash solvents in a shed until ca. 1993. Since that time the areas is used for storage of bins and miscellaneous equipment. The northern portion of the West Yard (Niagara Yard) once was a parking area for buses owned by Wisconsin Coach Lines. Extensive soil and groundwater sampling has been previously conducted in this area.

17. **Electrical substations** – Three electrical substations are located at the facility (Figure 2): the North Substation at the corner of Niagara Street and Roosevelt Place, the West Substation south of Building 29, and the East Substation between Building 16 and Building 17. Transformers in these substations likely contained dielectric oils containing PCBs.

18. **Floor Drains** – Seven (7) floor drains were observed in buildings 1, 1-1, 1A, 17, and 25 that could have accumulated spilled solids.

19. **Storm drains** – Twenty (20) catch basins located in the Central Alleyway, East Yard, and Roosevelt Place may have accumulated sediment impacted from spills or leaks from equipment and may have received infiltration of impacted groundwater.

## 2.2 Physiographical and Geological Setting

### 2.2.1 Site Topography

The foundry is located at the base of sloping terrain to the north and south along an unnamed creek bed that is conveyed beneath the plant in a large-diameter storm drain. The site slopes to the west and south, with surface elevations at the site ranging from approximately 860 feet MSL at the northeast corner of the property to approximately 830 feet MSL at the southwest corner of the property. An active railroad corridor is present to the west of the site. Drainage culverts are present on the northern and southern property boundaries along the roads. The unnamed creek flows through beneath the property through large culverts into the Lower Barstow Impoundment of the Fox River.

### 2.2.2 Site Geology

The facility is underlain by unconsolidated deposits consisting of an unsorted mixture of clay, silt, sand, and gravel comprising glacial drift and fill that includes foundry sand, crushed stone and soil. The overburden thickness varies in thickness from approximately 15 to 23 feet bgs, generally increasing in thickness to the west. The principal stratigraphic unit of the glacial drift is the New Berlin Formation. The New Berlin Formation is subdivided into upper and lower units. The upper unit is composed of gravely sandy loam till that extends to a depth of approximately 35 feet. Beneath this unit is a sand and gravel unit interpreted as outwash sediment. The entire sequence of basal till and sand and gravel lenses comprises the New Berlin Formation at the site (Schneider, 1983). The New Berlin Formation overlies Silurian bedrock of the Niagara dolomite. The elevation of the top of bedrock decreases from approximately 819 MSL to 809 MSL from east to west across the site. The Niagara dolomite is approximately 200 feet in thickness in the Waukesha area (RMT 1999).

### 2.2.3 Site Hydrogeology

Groundwater is typically first encountered at depths ranging from 8 to 17 feet below ground surface (bgs). The groundwater elevations range from approximately 823 to 815 feet above mean sea level (MSL). Groundwater is typically encountered in the outwash deposits of the lower New Berlin Formation, however the bedrock surface is differentially weathered causing groundwater to also be first encountered within the dolomite bedrock. Shallow horizontal groundwater flow in the outwash and weathered dolomite beneath sites is to the west towards the Fox River. The elevation of the Fox River is maintained by a dam in Frame Park at an approximate elevation of 810 feet MSL.

Deeper groundwater flow is primarily driven by fracture flow and flowpaths may vary from the shallow flow system. The groundwater flow direction may be impacted by dewatering of the active Waukesha Lime and Stone East Quarry located approximately 4000 feet north of the facility.

The principle sources of groundwater in eastern Waukesha County are the unconsolidated sand and gravel, the shallow Niagara dolomite, and the deep sandstone aquifer. According to WDNR water well records, the vast majority of groundwater used in the City of Waukesha is provided by the deep sandstone aquifer, although some private wells are screened in the Niagara dolomite and the unconsolidated sand and gravel. The sandstone aquifer is separated from the sand and gravel, and the Niagara aquifers, by the Maquoketa Shale which acts as a confining layer (Schneider, 1983).

# Section 3
# Site Investigation Plan

Additional investigative activity is necessary to determine if individual process areas within the facility identified as AOCs have impacted soil and/or groundwater. In addition, the extent of CVOCs in groundwater have not been fully delineated. A two-phase site investigation is presented in this section: Phase 1 will address the AOCs and provide data to possibly refine the placement of groundwater monitoring wells, and Phase 2 will include installation and sampling of the groundwater monitoring network to determine the extent of the CVOCs. This section describes the scope of these investigations and the techniques that will be used to accomplish them. All subsurface investigative activity will be conducted under the supervision of a Wisconsin Professional Geologist.

## 3.1 Phase 1 Site Investigation – AOCs

This field effort for this investigation is complicated by the several factors that could influence the ability to characterize each area. Considerable effort has been expended to establish boring locations for each of these areas and in each case a good faith effort was made to balance these decisions to provide the necessary data within the following limitations:

- The foundry is a working environment. A foundry includes dangerous work environments including hot work and heavy machinery. There is considerable activity that includes movement of large equipment, fork lift operations, and truck traffic. Locations of borings and wells has taken into account the safety of both TRC and its subcontractors and RMG workers.
- The foundry is on a compact site with considerable infrastructure. There are numerous overhead obstacles, buried utilities, and limited egress areas that severely limit the location of borings and wells. In addition, several monitoring wells have already been lost or damaged because they were placed in traffic areas. Care will be taken to place monitoring wells in areas that have lesser chances of being damaged or destroyed.
- Navistar does not own the operating facility and cannot dictate work schedules or traffic. Monitoring wells placed in areas that have a decreased impact on the day-to-day work activities are preferable.

In light of these efforts, the proposed boring and monitoring well locations shown on Figure 2 and Figure 3 are approximate, and may have to be modified slightly based on site conditions at the time of drilling due to underground or overhead utilities, presence of large equipment, or other logistical or safety concerns.

Table 1 is a summary of the AOCs and includes the soil and groundwater investigative activity proposed for each. Twenty-five (25) soil borings (GP-30 through GP-54) will be advanced to refusal using direct push techniques, and temporary wells will be installed to obtain groundwater analytical data from 10 of those borings. Sediment in floor drains (seven locations) and catch basins (20 locations) will also be sampled. Table 2 summarizes the soil sampling program and Table 3 summarizes the groundwater sampling program. The site investigation will follow requirements of NR 716 as follows:

- TRC will log each soil boring using the Unified Soil Classification System (USCS), and field screen soil in the field for odors, visual signs of contamination, and organic vapors using a photoionization detector (PID) equipped with an appropriate lamp to detect CVOCs. Logs will be completed using WDNR Form 4400-122 Rev 7-98 and signed by the individual that oversaw the drilling and sampling.
- TRC will collect soil samples continuously from each boring with four (4) unsaturated soil samples per boring submitted for laboratory analysis at 2-foot intervals (i.e. 0-2 feet, 2-4 feet, etc.) to a maximum depth of 8 feet. Selection of sample intervals may be modified at the discretion of the TRC on-site geologist based on sample recovery, nature of the material, or other unanticipated conditions that may jeopardize the quality of the sample.
- Samples selected for laboratory analysis will be numbered in the same manner as conducted in the 2014 investigation using the boring identifier followed by the sample depth interval as follows: GP-30, 2-4; GP-30, 4-6; etc.
- Samples will be preserved in a cooler packed with ice and maintained at a temperature no greater than 4°C and shipped or transported via courier to a Wisconsin certified laboratory. Proper chain-of-custody (COC) will be maintained at all times and documented on a COC form.
- An estimated 129 subsurface soil samples will be analyzed for the parameters listed in Table 1 and Table 2. An appropriate number of quality assurance/quality control (QA/QC) samples will also be collected and analyzed including 1 temperature and 1 trip blank per cooler.
- Each boring location will be located using a handheld Trimble global positioning system (GPS) capable of sub-foot accuracy. For borings located inside of buildings, the location of each boring will be measured off of several column lines or other fixed control with appropriate notes and photographs to ensure proper location.
- Abandon each boring according to NR 141.25.
- Borings at locations where a release had the potential for impacting groundwater and could reach the saturated zone will have a temporary well installed. The temporary well will be constructed of 1-inch diameter polyvinyl chloride (PVC) with a screen constructed of 10 feet of machine cut slots measuring 0.010-inch. An appropriately-sized sand pack will

be installed around the screened interval. The temporary well will be sampled and analyzed for parameters as listed in Table 3. Temporary wells will be properly abandoned after sampled collection.

- Samples of sediment will be collected from seven (7) floor drains and 20 catch basins identified in Table 2 and shown on Figures 2 and 3. These samples will be analyzed for VOCs, PAHs, eight RCRA metals and PCBs. Accessing the sediment will likely require removal of the overlying grate. The sediment can then be sampled directly with hand tools or a bucket auger. If no sediment is present or the depth of the sediment cannot be reached with a hand auger (with extensions) it will not be sampled. No workers shall enter a catch basin to collect a sample if it is greater than 3 feet in depth.

## 3.2 Phase 2 Site Investigation - CVOC Plume Delineation

Delineation of the CVOC groundwater plume will be accomplished through installation of monitoring wells. The focus of this investigation is to delineate the extent of CVOCs in the shallow plume, as the shallow groundwater is of primary importance as a potential risk for vapor intrusion. This work plan is also designed to confirm or deny whether a secondary source area(s) is present beneath the facility by investigation of the area immediately upgradient of the WCL tank area and former solvent usage areas. The need for any further delineation of any potential source areas of groundwater contamination within the facility will also be assessed from the Phase 1 investigation. If the Phase 1 investigation identifies a new source of groundwater contamination, the need additional monitoring well(s) will be evaluated. WDNR will be notified of any plans to install additional monitoring wells. Vertical delineation of CVOCs in the bedrock aquifer will also be assessed during the groundwater investigation.

TRC will complete the following to determine the horizontal extent of CVOCs in the shallow groundwater:

- Mobilize drilling equipment capable of drilling shallow soil borings, monitoring wells, and within the facility itself. Multiple types of drilling equipment might be required. Drilling equipment will be decontaminated using a pressure washer: 1) prior to drilling, 2) after drilling each hole, and 3) before departing the site.
- Drill, install, and develop 13 new water table monitoring wells (MW-25 through MW-37). The approximate locations for those wells are shown on Figure 2. It is anticipated that the monitoring wells installed out-of-doors will be installed using rotary sonic or rotary drilling methods, while the two monitoring wells installed inside the facility will be installed using a similar method using a drilling rig that can access the interior of the facility. Samples of subsurface materials will be continuously logged by an experienced TRC geologist. Drilling will likely be advanced into bedrock at most locations; estimated to be 15-30 feet bgs. The geology nearer the Fox River (e.g., MW-36 and MW-37) is unknown and the depth to bedrock may be deeper. Those water table monitoring wells may be

installed entirely in overburden. Elsewhere, monitoring wells may have to penetrate up to 15 feet into bedrock to properly accommodate the 10 feet of well screen and intersect the water table. Monitoring wells will be installed in accordance with NR 141.

- Attempt to repair MW-11 (protective cover only), MW-16 and MW-24. If repair is not possible, abandon the wells in accordance with NR 141.25 (2) (b). MW-24 will be replaced, but moved to an area in close proximity that is in a less active portion of the East Yard.
- The rationale for the location of the proposed monitoring wells are as follows:
  - New monitoring wells MW-25, -26, -29, -36, and -37 will serve to delineate the hydrologically downgradient extent of the CVOC plume. MW-29 is also located at the location of a former auto dealership. Soil may be sampled from this well boring if any signs of impact are noted by the TRC onsite geologist.
  - MW-27, MW-28, and MW-35 are positioned to determine the lateral (side gradient) extent of the CVOC plume. MW-28 is also positioned to investigate the former Salvage Yard.
  - MW-30 and MW-31 are positioned to follow the plume axis upgradient to determine the existence of any potential "hot spot" of CVOCs beneath the former Navistar facility. MW-30 is located in the closest accessible location to the core room where solvents were most often used. MW-31 is also located immediately adjacent to a 40-inch storm drain that runs through an alleyway between buildings and could have served as a preferential pathway and/or potential source of CVOCs.
  - MW-32 and MW-33 are located within the facility boundaries and located downgradient of former solvent usage areas and previous core wash areas in Buildings 7B and 7E (Appendix A) to determine if these areas contributed to the CVOC plume. The locations of former core wash areas at the eastern end of the facility are inaccessible, so the location MW-33 was placed in a downgradient position to those potential source areas. The proposed location of MW-32 was moved approximately 140 feet northwest of its former location (i.e. Revision 1) to place it directly in the former Refuse Pit location as determined from recently obtained maps.
  - Storm drains and sanitary sewers drain to the south to join the municipal sewer that is runs through the plant approximately 150 feet north of, and parallel to, Perkins Avenue. Note that monitoring well locations MW-31, MW-32, and MW-33 are located in close proximity to these potential pathways. In addition, the Phase 1 investigation will provide samples from catch basins that may determine if modifications should be made to proposed monitoring well network.
  - MW-34 will serve to determine groundwater conditions near the former location of five underground storage tanks and ASTs in the East Yard and determine if CVOCs are migrating from upgradient of the property.

- Deep monitoring wells (NMW-9D, MW-24D, and MW-29D) will be installed to provide an initial assessment of the deeper bedrock aquifer. These wells are to be installed adjacent to a neighboring shallow well (i.e. NMW-9, MW-24, and MW-29) to provide a "well nest". The locations for the deep wells are positioned to provide one well (MW-24D) in the vicinity of the area of highest concentrations with two additional wells at the west (downgradient) property boundary. If the extent of contamination is found to extend beyond these wells (vertically and horizontally) the need for an additional subsurface investigation will be evaluated to adequately determine the extent of CVOCs in the fractured bedrock aquifer.
- Surface water samples will be collected from Hobo Spring and the unnamed creek upstream and downstream of the facility (Figure 2) to determine if CVOCs are present in this stream. Samples will be collected using a peristaltic pump for the spring if possible, otherwise samples will be collected by "direct fill" sampling. The location of these samples will be recorded using a handheld Trimble GPS unit capable of sub-foot accuracy.

- Log each well boring using the Unified Soil Classification System (USCS) for the overburden, and bedrock described using applicable sections of ASTM Method D2113 and field screen the samples in the field for odors, visual signs of contamination, and using a PID. Logs will be completed using WDNR Form 4400-122 Rev 7-98 and signed by the individual that oversaw the drilling and sampling.
- Soil samples will be collected from well borings inside the facility (MW-30, MW-31, MW-32, MW-33, and MW-34) at 2-foot intervals (i.e. 0-2 feet, 2-4 feet, etc.) to the top of the saturated zone, or 8 feet bgs. PID readings and visual observations of the material will be used to determine the actual material within those intervals to be placed in the sample vial by the TRC on-site geologist. An estimated four soil samples per boring (total of 20) will be analyzed for the parameters listed in Table 2. An appropriate number of quality assurance/quality control (QA/QC) samples will also be collected and analyzed (1 duplicate per 20 samples; 1 decontamination blank per day; 1 trip blank per cooler with VOC samples).
- Monitoring well screens and risers will be constructed of 2-inch diameter, Schedule 40 PVC with screens constructed of 10 feet of machine cut slots measuring 0.010-inch. An appropriately-sized sand pack will be installed in accordance with NR 141.11, overlain by a filter pack seal and annular space seal as per NR 141.13. Wells will be completed as flush-mounted completions in steel drive-over boxes and fitted with a locking friction fitting well top.
- Deep monitoring wells will be drilled to an approximate depth of 60 feet below ground surface and will be designed identically to the shallow wells except the well screens will be 5 feet in length with appropriate thicknesses of sand pack, well seal and annular seal in accordance with NR 141.

- Each monitoring well will be developed by surging, bailing, or pumping until returns are clear as per NR 141.21.
- Each completed monitoring well will be labeled and assigned a Wisconsin unique well identifier to be included on field forms.
- Once all monitoring wells are installed, groundwater samples will be collected from the 13 new and 12 previously existing monitoring wells and on a quarterly basis thereafter until a minimum of eight rounds of groundwater samples have been collected at each well. Locations of all existing and proposed monitoring wells are illustrated on Figure 3.
- Analytical results will be forwarded to WDNR within 10 business days of receipt of the data in accordance with NR 716.14 with a brief analysis of whether the results indicate a revision to the sampling network is necessary.
- Sample vials will be pre-preserved by the laboratory and will be further preserved in a cooler packed with ice and maintained at a temperature not to exceed 4°C and not allowed to freeze, and shipped or transported via courier or common carrier to a Wisconsin-certified laboratory. Proper chain-of-custody will be maintained at all times and documented on a chain of custody form.
- Groundwater samples will be sampled using low-flow sampling techniques using a peristaltic, bladder or centrifugal sampling pump and analyzed for water quality parameters and monitored natural attenuation parameters (i.e. nitrate, manganese, iron, chloride, alkalinity, sulfate, and TOC) by EPA Methods listed on Table 3 by a Wisconsin- certified laboratory.
- Collect field parameters (water level, pH, specific conductance, temperature, oxidation-reduction potential, and dissolved oxygen) to support purge water stabilization criteria and provide aqueous geochemistry data at each monitoring well and surface water location.
- Collect quality assurance/quality control samples (1 duplicate per 10 samples; 1 trip blank and 1 temperature blank per cooler), as per industry practice. A field blank sample of water used in drilling will also be collected.
- Conduct a vertical and horizontal survey of all new monitoring wells. Wells will be surveyed to State Plane Coordinates by a Wisconsin-licensed surveyor. The surveyed coordinates will be provided to WDNR and recorded on the boring and well completion logs. The accuracy of the survey will be to the nearest 0.01 foot or less.
- Conduct hydraulic conductivity testing (slug testing) on up to nine wells once initial sampling has been completed. Testing will use a pressure transducer and a pneumatic or solid slug. Slug test analysis will use appropriate methods of analysis through AQTESOLV™ software to estimate hydraulic conductivity values for the aquifer at each well.

## 3.3 Investigative Derived Waste

Soil/bedrock cuttings, well development water, and purge water generated during the site investigation will be containerized and characterized for proper disposal by Navistar. Solids and aqueous materials will be containerized separately. Personal protective equipment (PPE) will be disposed with general site refuse.

## 3.4 Vapor Intrusion Study

A vapor intrusion pathway screening assessment of the Navistar facility and the surrounding properties will conducted per WDNR guidance (WDNR 2010). The screening assessment is included as Appendix C of the Vapor Intrusion Work Plan, provided as Appendix B. If the screening assessment indicates the potential for vapor migration at a property, that property was included in the vapor intrusion work plan. The work plan includes the locations, methods, and procedures used to sample vapor in residential and commercial properties. If the CVOC groundwater plume is found to underlie a property from the field investigation as defined through implementation of this supplemental site investigation (or other criteria as specified in guidance (WDNR 2010), the property owner will be identified and a strategy will be developed for notifying the owners for vapor sampling in a future investigation.

# Section 4
# Documentation and Reporting

TRC will prepare a site-specific Health and Safety Plan (HASP) prior to any field activity. This HASP will be provided to the TRC field team and subcontractor(s) and to RMG. The field team will conduct daily safety meetings and attendance at these meetings will be recorded and retained.

Daily field activities will be recorded in serially numbered field logbook(s). Documentation may also be recorded on field forms but those forms should be referenced in the field logbook. The logbook entries should be signed daily by the person responsible the entries on that day. No field notes should be destroyed or discarded. Corrections to the field logbook should be struck through with a single line, initials and dated. The logbook should include any site visitors and document daily safety tailgate meetings as well as observations of the weather, technical notes, equipment calibration, problems encountered, and daily progress. Once a field logbook is completed or at the end of the field effort, the logbook(s) will be collected by the project manager. Notes on well drilling, installation, development, and sampling will be recorded on appropriate field logs to be provided to the WDNR.

TRC will tabulate and evaluate the results of the site investigation prior to preparation of a Site Investigation Report. TRC will present these initial results to WDNR for their information and discuss the results via telephone meeting. If the extent of contamination has been delineated, TRC will summarize those data with appropriate tables and figures and include a work plan for the soil vapor assessment of the CVOC plume. If the plume has not been delineated, TRC will prepare a work plan addendum to complete the plume delineation and provide the data summary and work plan once the plume delineation is complete.

Once the data for this supplemental site investigation has been completed, Navistar will compile and present the investigation results into a comprehensive Site Investigation Report to be submitted to the WDNR within 60 days upon receipt of the final laboratory data. The report will include a revised water table contour map, new geologic cross sections, and updated CVOC isoconcentration maps. All well drilling logs, well completion, well development, sampling forms, and hydraulic conductivity testing calculations will be provided in the report. The report will include a determination of whether the lateral extent of contamination has been sufficiently characterized and provide recommendations if further plume delineation is necessary. Navistar will then prepare and submit a Remedial Action Options Report to WDNR within 60 days of submittal of the Site Investigation Report or as indicated per WDNR comments.

Quarterly groundwater sampling events will continue throughout preparation of these submittals. Analytical results of these events will be included with the above submittals as they are received, or will be submitted separately with a brief summary of results once the above deliverables have been completed.

# Section 5
# Project Schedule

The following is a milestone schedule for upcoming events at the site beyond what is discussed in this work plan. This schedule is highly contingent on WDNR approvals, permitting, and offsite access issues that could cause delays. Updates to this schedule will be submitted to WDNR as necessary.

- **May 2017** – Prepare and submit Revision 2 SSI work plan and vapor intrusion evaluation work plan
- **June/July 2017** – WDNR review and approval of SSI work plan and vapor intrusion evaluation work plan
  - Implementation of SSI work plan - Phase 1
  - Negotiate access agreements and implement community outreach for vapor intrusion assessment
- **July/August 2017** – Implement vapor evaluation work plan field work.
  - Collect initial vapor samples
- **September 2017** – Phase 2 implementation of SSI work plan (monitoring well installation)
- **September/October 2017** – Sample surface water and all monitoring wells (1st round for new wells)
  - Review and analyze initial vapor analytical results
- **November 2017** – Submit groundwater and vapor analytical data to WDNR (1st round)
- **December 2017** – Sample all monitoring wells and vapor ports (2nd round)
- **January 2018** – Submit first semi-annual report
- **February 2018** – Submit groundwater and vapor analytical data (2nd round)
- **March 2018** – Sample new monitoring wells and vapor ports, if required (3rd round)
- **May 2018** – Submit analytical data (3rd round)
- **June 2018** – Submit SI report (inclusive of vapor evaluation report)
  - Sample new monitoring wells (4th round)
- **August 2018** – Submit second semi-annual report
- **September 2018** – Submit Remedial Action Options Report (RAOR)
- **Winter/Spring 2019** – Submit groundwater analytical data (4th round)
  - Receive comments on RAOR and gain approval
  - Initiate Design & Construction (as appropriate)

# Section 6
# References


PM Environmental Inc. 2014. DRAFT Phase I Environmental Site Assessment of the Iron Foundry Property Located at 1401 Perkins Avenue, Waukesha, Wisconsin. Prepared for: RMG, LLC. Prepared by: PM Environmental, Inc. Chicago, Illinois. December 2014.

RMT, Inc. 1993. Preliminary Groundwater Investigation at the Navistar International Transportation Corporation Casting Facility Waukesha, Wisconsin. Prepared by RMT, Inc., Madison, Wisconsin. April 1993.

RMT, Inc. 1998. Phase II Site Investigation Work Plan. Prepared for Navistar International Transportation Corporation Waukesha facility. Prepared by RMT, Inc., Brookfield, Wisconsin. March 1998.

RMT, Inc. 1999. Phase II Supplemental Site Investigation Report Navistar International Transportation Corporation Waukesha, Wisconsin. Prepared for Navistar International Transportation Corporation Chicago, Illinois. Prepared by RMT, Inc., Brookfield and Madison, Wisconsin. February 1999.

Schneider, A.F. 1983. Wisconsin stratigraphic and glacial sequence in southeastern Wisconsin, in D.M. Mickelson and L. Clayton (eds). Late Pleistocene history of southeastern Wisconsin. Wisconsin Geological and Natural History Survey, Geoscience Wisconsin, Vol. 7, p. 59-85.

TRC, Inc. 2015. Site Investigation Report Renaissance Manufacturing Group Waukesha Foundry 1401 Perkins Avenue Waukesha, Wisconsin. BRRTS #02-68-098404. August 2015. Prepared by TRC Environmental Corporation Madison, Wisconsin.

WDNR. 2010. Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin. PUB-RR-800. December 2010. (updated July 2012).

Table 1
AOC Summary and Proposed Investigations

| AOC NUMBER | AOC NAME AND DESCRIPTION (constituents of concern) | EXISTING DATA | PROPOSED INVESTIGATION (analytes) |
|---|---|---|---|
| 1 | **NMW-3R Soil**<br>CVOC-impacted soil | GP-16, GP-17, GP-18, NWM-3 | GP-30, GP-31, GP-32, GP-33<br>(VOCs) |
| 2 | **Foundry Fill**<br>Foundry waste used as fill material | Numerous borings on west side have sampled foundry fill and analyzed it for VOCs | Five (5) samples of foundry fill encountered during the subsurface investigation<br>(PAHs, metals) |
| 3 | **Building 29 – Core Room**<br>Used for core wash operations since 1973. | NAV-5, NAV-6, SB-7, SB-8, SB-9, SB-10, NMW-2, MW-23 | MW-30<br>(VOCs) |
| 4 | **Building 7 / 7A**<br>Former core room, present melting/pouring line | HA-1, SB-9, SB-10, SB-18, SB-19, SB-20, SB-22, NMW-10, NMW-11 | MW-31<br>(VOCs, PAHs) |
| 5 | **Building 7B**<br>Former and present molding room; includes Refuse Pit | NAV-4 | MW-32<br>(VOCs, PAHs, metals, PCBs) |
| 6 | **Buildings 7E / 1**<br>Former core wash area; former parts cleaner in Building 1 | None | MW-33<br>(VOCs, PAHs) |
| 7 | **Buildings 20 / 22**<br>Former core room and storage with kerosene UST (removed) | None | GP/TW-34<br>(VOCs, PAHs) |
| 8 | **Building 4**<br>Annealing, painting, patterns, machine shop | None | GP/TW-36<br>(VOCs, PAHs, metals) |
| 9 | **Buildings 3 /15 / 16**<br>Annealing, painting, patterns, service/repair | NMW-4 | GP/TW-37<br>(VOCs, PAHs) |
| 10 | **Buildings 17 / 25**<br>Patterns, parts washer, machine shop, subgrade pits | None | GP-/TW-38<br>(VOCs, PAHs, metals) |
| 11 | **Building 30**<br>Foundry with machine shop | None | GP-/TW-54<br>(VOCs, PAHs, metals) |

Table 1
AOC Summary and Proposed Investigations

| AOC NUMBER | AOC NAME AND DESCRIPTION (constituents of concern) | EXISTING DATA | PROPOSED INVESTIGATION (analytes) |
|---|---|---|---|
| 12 | **Salvage Yard / HAZMAT area**<br>Unpaved salvage yard with former USTs and ASTs; current hazardous / nonhazardous storage area | None | MW-28, GP/TW-39, GP-40, GP/TW-41, GP-42<br>(VOCs, PAHs, metals, PCBs) |
| 13 | **Remaining USTs**<br>Two, 20,000 gallon #6 heating oil tanks abandoned in place | None | GP/TW-43<br>(VOCs, PAHs) |
| 14 | **Central Alleyway**<br>Former USTs, ASTs, railway spur | None | GP/TW-53<br>(VOCs, PAHs) |
| 15 | **East (Cleveland) Yard**<br>Solvent storage, ASTs, USTs | NAV-1 | MW-34, GP-/TW-35<br>(VOCs, PAHs) |
| 16 | **West (Whiterock / Niagara) Yard**<br>Stored core oil drums in shed, miscellaneous equipment storage, junkyard for busses | GP-1, GP-2, GP-3, GP-4, GP-5, GP-6, GP-25, GP-26, GP-27, GP-28, GP-29, NAV-3, SB-25, SB-26, NMW-1, NMW-7, NMW-8R, NMW-9, MW-6, MW-11, MW-12, MW-13, MW-15, MW-16, MW-23, MW-24 | MW-9D, MW-24D, MW-29D<br>(VOCs – deep groundwater) |
| 17 | **Electrical substations**<br>Transformers with dielectric fluid that historically contained PCBs | None | North - GP-44, GP-45, GP-46<br>West - GP-47, GP-48, GP-49<br>East - GP-50, GP-51, GP-52<br>(PCBs) |
| 18 | **Floor Drains**<br>Seven (7) floor drains in five buildings with ongoing operations | None | FD-1, FD-2, FD-3, FD-4, FD-5, FD-6, FD-7<br>(VOCs, PAHs, metals, PCBs) |
| 19 | **Storm drains**<br>Twenty (20) catch basins located in areas that may have received runoff from impacted areas | None | CB-1 through CB-20<br>(VOCs, PAHs, metals, PCBs) |

Notes:
VOCs analyzed by EPA 8260
PAHs analyzed by EPA 8270
RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) analyzed by EPA 6010/7470/7471
PCBs analyzed by EPA 8082

Table 2
Sampling Summary - Soil/Sediment
Navistar Supplemental Site Investigation

| AOC # | SITE ID(s) | ID # | VOCs | PAHs | METALS | PCBs |
|---|---|---|---|---|---|---|
| 1 | NMW-3R | GP-30 | 4 | -- | -- | -- |
| | | GP-31 | 4 | -- | -- | -- |
| | | GP-32 | 4 | -- | -- | -- |
| | | GP-33 | 4 | -- | -- | -- |
| 2 | Foundry fill | TBD | 5 | 5 | 5 | 5 |
| 3 | Bldg. 29 | MW-30 | 4 | -- | -- | -- |
| 4 | Bldg. 7 / 7A | MW-31 | 4 | 4 | -- | -- |
| 5 | Bldg. 7B | MW-32 | 4 | 4 | 4 | 4 |
| 6 | Bldg. 7E / 1 | MW-33 | 4 | 4 | 4 | -- |
| 7 | Bldg. 20, 22 | GP-/TW-34 | 4 | 4 | -- | -- |
| 8 | Bldg. 4 | GP-/TW-36 | 4 | 4 | 4 | -- |
| 9 | Bldgs. 3 /15/ 16 | GP-/TW-37 | 4 | 4 | -- | -- |
| 10 | Bldgs. 17 / 25 | GP-/TW-38 | 4 | 4 | 4 | |
| 11 | Bldg. 30 | GP-/TW-54 | 4 | 4 | 4 | -- |
| 12 | Salvage Yard/HAZMAT | MW-28 | 4 | 4 | 4 | 4 |
| | | GP-/TW-39 | 4 | 4 | 4 | 4 |
| | | GP-40 | 4 | 4 | 4 | 4 |
| | | GP-/TW-41 | 4 | 4 | 4 | 4 |
| | | GP-42 | 4 | 4 | 4 | 4 |
| 13 | Remaining USTs | GP-/TW-43 | 4 | 4 | -- | -- |
| 14 | Central Alleyway | GP-/TW-53 | 4 | 4 | -- | -- |
| 15 | East Yard | MW-34 | 4 | 4 | -- | -- |
| | | GP-/TW-35 | 4 | 4 | -- | -- |
| 16 | West Yard | MW-9D | -- | -- | -- | -- |
| | | MW-24D | -- | -- | -- | -- |
| | | MW-29D | -- | -- | -- | -- |
| 17 | North Substation | GP-44 | -- | -- | -- | 4 |
| | | GP-45 | -- | -- | -- | 4 |
| | | GP-46 | -- | -- | -- | 4 |
| | West Substation | GP-47 | -- | -- | -- | 4 |
| | | GP-48 | -- | -- | -- | 4 |
| | | GP-49 | -- | -- | -- | 4 |
| | East Substation | GP-50 | -- | -- | -- | 4 |
| | | GP-51 | -- | -- | -- | 4 |
| | | GP-52 | -- | -- | -- | 4 |
| 18 | Floor Drains | FD-1…FD-7 | 7 | 7 | 7 | 7 |
| 19 | Catch Basins | CB-1…CB-20 | 20 | 20 | 20 | 20 |
| | QA/QC Duplicates | 1 per 20 | 7 | 6 | 2 | 3 |
| | Decontamination blanks | 1 per day | 5 | 5 | 5 | 5 |
| | **Totals** | | 132 | 111 | 79 | 100 |

Notes:

1) Subsurface soil samples collected at 2 ft intervals to 8 feet below ground surface (0-2, 2-4, 4-6, 6-8).

2) TBD - Location to be determined. Five samples from borings that encounter foundry material as fill.

3) Soil samples may be collected from MW-9D, MW-24D, and MW-29D if visual indication or PID readings suggest impacts.

4) VOCs analyzed by EPA 8260, PAHs analyzed by EPA 8270, RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) analyzed by EPA 6010/7470/7471, PCBs analyzed by EPA 8082

Table 3
Sampling Summary - Groundwater
Navistar Supplemental Site Investigation

| AOC # | SITE ID(s) | ID # | VOCs | PAHs | METALS | MNA |
|---|---|---|---|---|---|---|
| 1 | NMW-3R | GP-30 | -- | -- | -- | -- |
| | | GP-31 | -- | -- | -- | -- |
| | | GP-32 | -- | -- | -- | -- |
| | | GP-33 | -- | -- | -- | -- |
| 2 | Foundry fill | TBD | -- | -- | -- | -- |
| 3 | Bldg. 29 | **MW-30** | 8 | -- | -- | 8 |
| 4 | Bldg. 7 / 7A | **MW-31** | 8 | 1 | -- | 8 |
| 5 | Bldg. 7B | **MW-32** | 8 | 1 | 1 | 8 |
| 6 | Bldg. 7E / 1 | **MW-33** | 8 | 1 | 1 | 8 |
| 7 | Bldg. 20, 22 | GP-/TW-34 | 1 | 1 | -- | -- |
| 8 | Bldg. 4 | GP-/TW-36 | 1 | 1 | 1 | -- |
| 9 | Bldgs. 3 /15/ 16 | GP-/TW-37 | 1 | 1 | -- | -- |
| 10 | Bldgs. 17 / 25 | GP-/TW-38 | 1 | 1 | 1 | |
| 11 | Bldg. 30 | GP-/TW-54 | 1 | 1 | 1 | -- |
| 12 | Salvage Yard/HAZMAT | **MW-28** | 8 | 1 | 1 | 8 |
| | | GP-/TW-39 | 1 | 1 | 1 | -- |
| | | GP-40 | -- | -- | -- | -- |
| | | GP-/TW-41 | 1 | 1 | 1 | -- |
| | | GP-42 | -- | -- | -- | -- |
| 13 | Remaining USTs | GP-/TW-43 | 1 | 1 | -- | -- |
| 14 | Central Alleyway | GP-/TW-53 | 1 | 1 | -- | -- |
| 15 | East Yard | **MW-34** | 8 | 1 | -- | 8 |
| | | GP-/TW-35 | 1 | 1 | -- | -- |
| 16 | West Yard | **MW-9D** | 8 | -- | -- | 8 |
| | | **MW-24D** | 8 | -- | -- | 8 |
| | | **MW-29D** | 8 | -- | -- | 8 |
| 17 | North Substation | GP-44 | -- | -- | -- | -- |
| | | GP-45 | -- | -- | -- | -- |
| | | GP-46 | -- | -- | -- | -- |
| | West Substation | GP-47 | -- | -- | -- | -- |
| | | GP-48 | -- | -- | -- | -- |
| | | GP-49 | -- | -- | -- | -- |
| | East Substation | GP-50 | -- | -- | -- | -- |
| | | GP-51 | -- | -- | -- | -- |
| | | GP-52 | -- | -- | -- | -- |
| 18 | Floor Drains | FD-1…FD-7 | -- | -- | -- | -- |
| 19 | Catch Basins | CB-1…CB-20 | -- | -- | -- | -- |

Table 3
Sampling Summary - Groundwater
Navistar Supplemental Site Investigation

| AOC # | SITE ID(s) | ID # | VOCs | PAHs | METALS | MNA |
|---|---|---|---|---|---|---|
| CVOC Plume | Offsite | NMW-1 | 8 | -- | -- | 8 |
| | | NMW-3R | 8 | -- | -- | 8 |
| | | NMW-4 | 8 | -- | -- | 8 |
| | | NMW-7 | 8 | -- | -- | 8 |
| | | NMW-8R | 8 | -- | -- | 8 |
| | | NMW-9 | 8 | -- | -- | 8 |
| | | MW-11 | 8 | -- | -- | 8 |
| | | MW-13 | 8 | -- | -- | 8 |
| | | MW-15 | 8 | -- | -- | 8 |
| | | MW-16 | 8 | -- | -- | 8 |
| | | MW-23 | 8 | -- | -- | 8 |
| | | MW-24 | 8 | -- | -- | 8 |
| | | **MW-25** | 8 | -- | -- | 8 |
| | | **MW-26** | 8 | -- | -- | 8 |
| | | **MW-27** | 8 | -- | -- | 8 |
| | | **MW-29** | 8 | -- | -- | 8 |
| | | **MW-35** | 8 | -- | -- | 8 |
| | | **MW-36** | 8 | -- | -- | 8 |
| | | **MW-37** | 8 | -- | -- | 8 |
| | | SW-UPSTREAM | 4 | -- | -- | 4 |
| | | SW-DOWNSTREAM | 4 | -- | -- | 4 |
| | | HOBO SPRING | 4 | -- | -- | 4 |
| | QA/QC Duplicates | 1 per 10 | 26 | 1 | 1 | 25 |
| | **Totals** | | 272 | 16 | 9 | 261 |

Notes:

1) CVOC Plume wells are sampled quarterly for two years

2) MW-28, -29, 32, -33, and -34 are sampled one time for additional parameters under this scope of work.

3) MNA parameters are: alkalinity, chloride, iron, manganese, nitrate, sulfate, total organic carbon.

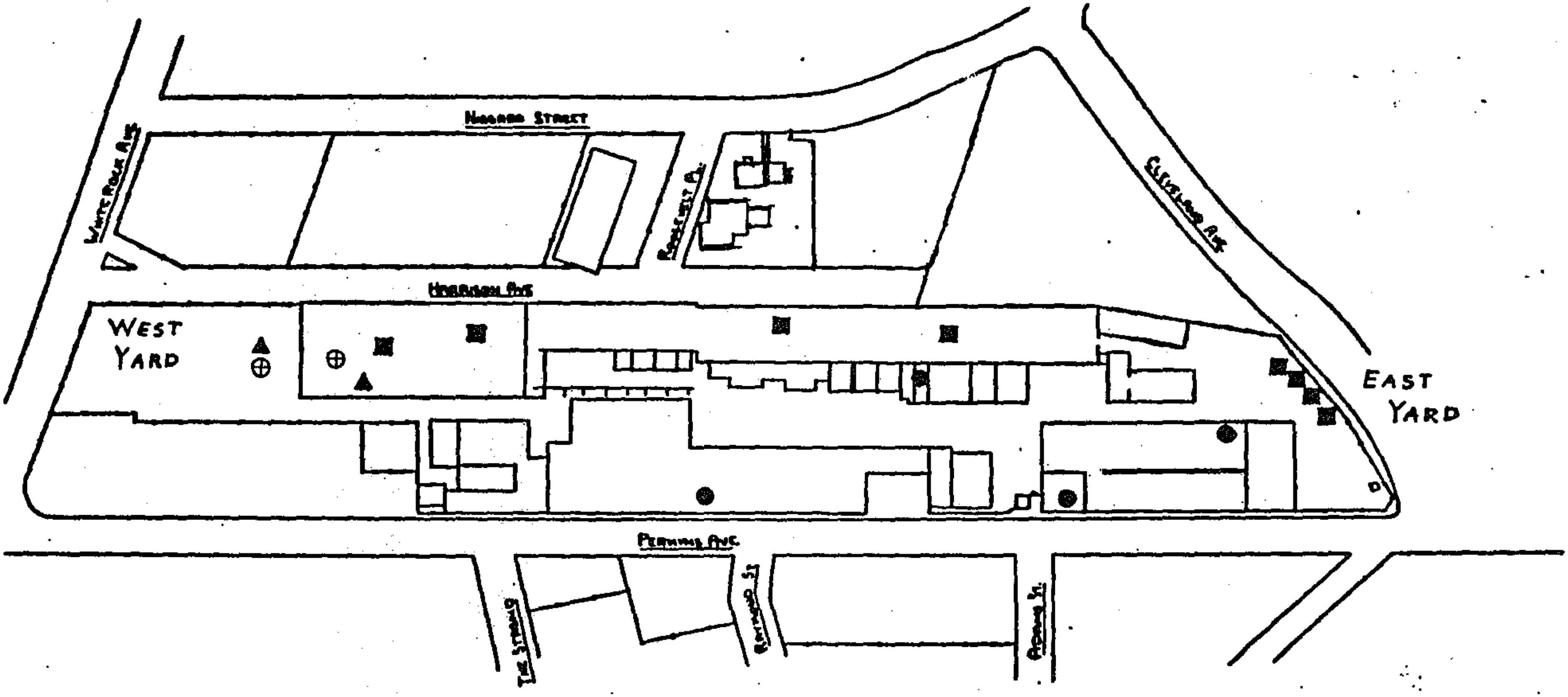
4) Field parameters (pH, temperature, specific conductance, dissolved oxygen, and ORP) to be collected at each well when sampled.

5) **New** monitoring wells are in **bold** font.

6) VOCs analyzed by EPA 8260, PAHs analyzed by EPA 8270, RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) analyzed by EPA 6010/7470/7471, PCBs analyzed by EPA 8082 MNA parameters will be analyzed as follows: alkalinity (EPA 310.2), sulfate, nitrate, and chloride (EPA 300.0), iron and manganese (EPA 6020), TOC (EPA 5310C).

# Appendix A
# Maps of Process Areas

# WAUKESHA CASTING FACILITY




● PARTS CLEANING

■ LIQUID PARTING

▲ CORE WASH

⊕ RELEASE AGENT

INTERNATIONAL HARVESTER COMPA

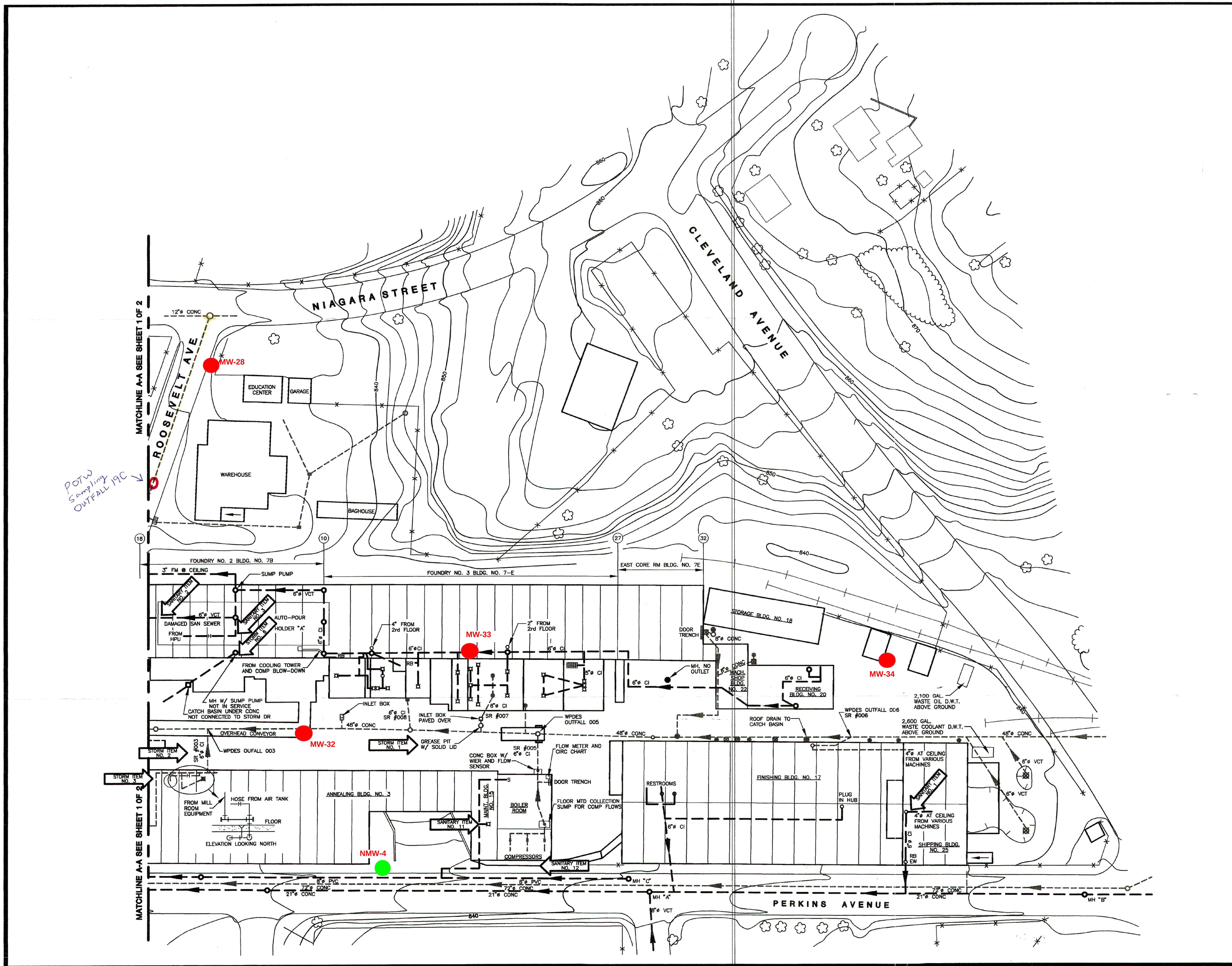
PLANT MAP


TOLERANCE UNLESS OTHERWISE NOTED
0.0 ± .03 0.000 ± .005
0.00 ± .01 0.0000 ± .0005
ANGLES ± 0° 30′

NAVISTAR INTERNATIONAL
WAUKESHA CASTING FACILITY

EXISTING SITE PLAN
NAVISTAR INTERNATIONAL

| DRAWN | MATERIAL | SCALE |
|---|---|---|
| K. BURKE | | 1"=50' |
| DATE | DWG. NO. | |
| 7-29-92 | F:\DWGS\PLANT\PLOT2 | |




## LEGEND

- EXISTING BUILDINGS
- FENCE
- PROPERTY LINE
- SANITARY SEWER
- STORM SEWER
- SANITARY MANHOLE
- RB REFRIGERATED BUBBLER
- S SINK
- T TOILET
- STORM MANHOLE
- ROOF DRAIN
- FLOOR DRAIN
- SUMP PUMP
- HPU HYD. POWER UNIT
- CATCH BASIN
- EW EYE WASH
- PROPOSED MONITOEING WELL
- EXISTING MONITRORING WELL

| NO. | BY | DATE | REVISION | APP'D. |
|---|---|---|---|---|
| 3. | | | | |
| 2. | | | | |
| 1. | | | | |

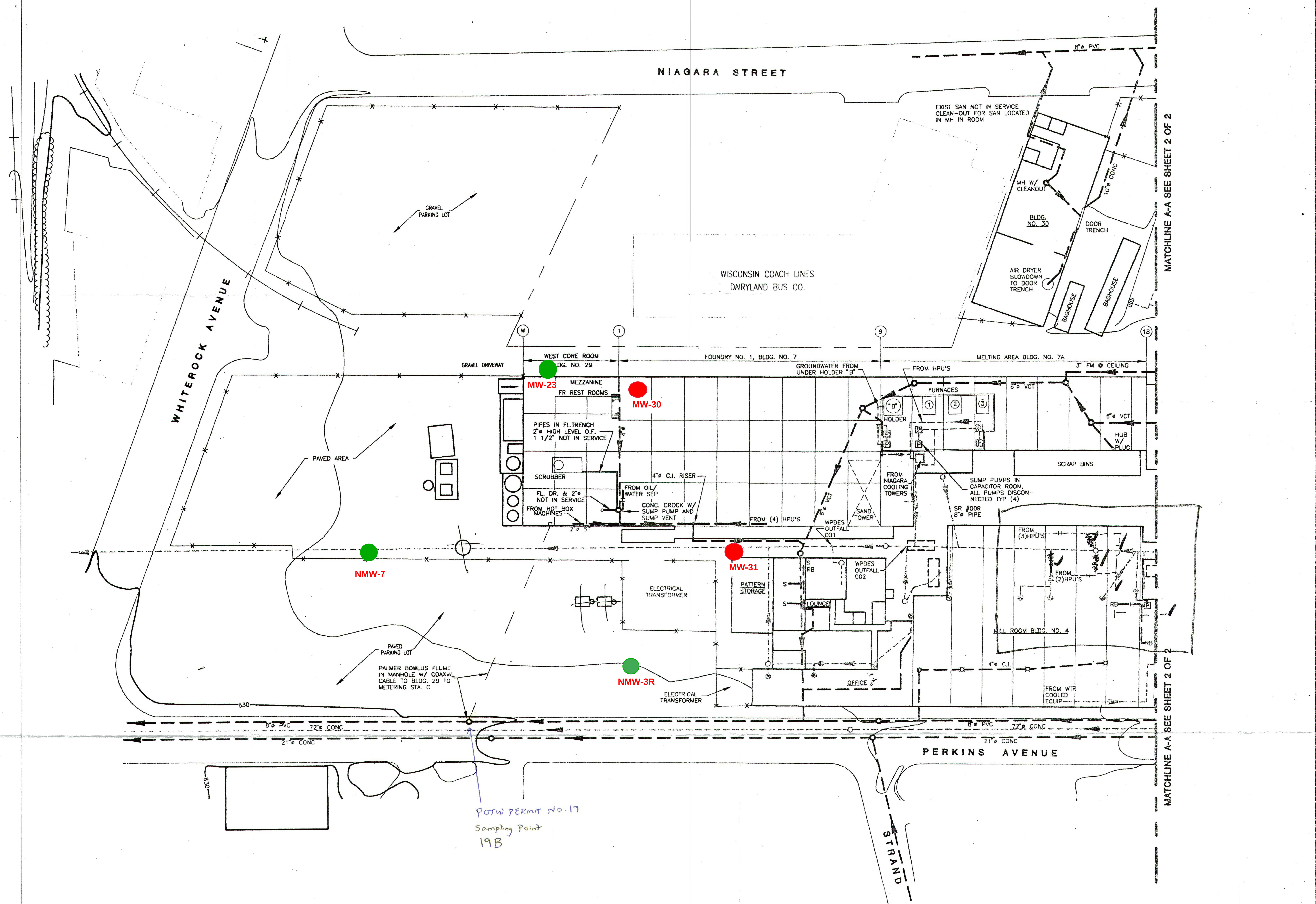
PROJECT: NAVISTAR INTERNATIONAL, INC.
UTILITY LAYOUT
WAUKESHA, WI

SHEET TITLE: SITE MAP
STORMWATER AND SANITARY
OUTFALLS AND CONNECTIONS

| | | |
|---|---|---|
| DRAWN BY: MHS | SCALE: AS NOTED | PROJ. NO. 2835.01 |
| CHECKED BY: | | DRWG. NO. |
| APPROVED BY: | DATE PRINTED: | FILE NO. 28350104 |
| DATE: SEPTEMBER, 1993 | | SHEET 2 OF 2 |

RMT INC.
20900 Swenson Drive
Suite 100
Waukesha, WI 53186-4050
Phone: 414-798-9550

DRAWING NO.




## LEGEND

- EXISTING BUILDINGS
- FENCE
- PROPERTY LINE
- SANITARY SEWER
- STORM SEWER
- SANITARY MANHOLE
- RB REFRIGERATED BUBBLER
- S SINK
- T TOILET
- STORM MANHOLE
- ROOF DRAIN
- FLOOR DRAIN
- SUMP PUMP
- HPU HYD. POWER UNIT
- CATCH BASIN
- EW EYE WASH
- PROPOSED MONITORING WELL
- EXISTING MONITORING WELL

SCALE: 1" = 40'

DRAWING NO.

| NO. | BY | DATE | REVISION | APP'D. |
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| 3. | | | | |
| 2. | | | | |
| 1. | | | | |

PROJECT: NAVISTAR INTERNATIONAL, INC. UTILITY LAYOUT WAUKESHA, WI

SHEET TITLE: SITE MAP STORMWATER AND SANITARY OUTFALLS AND CONNECTIONS

| | | |
|---|---|---|
| DRAWN BY: MHS | SCALE: AS NOTED | PROJ. NO. 2835.01 |
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# Appendix B
# Vapor Intrusion Investigation Work Plan

# Vapor Intrusion Investigation Work Plan Revision 1

## Former Navistar Foundry Facility
## 1401 Perkins Avenue
## Waukesha, Wisconsin

*BRRTS #02-68-098404*

May 2017

*Prepared for*
*Navistar, Inc.*
*Lisle, Illinois*


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# Section 1
# Introduction

## 1.1 Background

Navistar, Inc. (Navistar) requested a vapor intrusion evaluation from TRC Environmental Corporation (TRC) of the former Navistar facility and surrounding properties as part of the case closure efforts for Wisconsin Department of Natural Resources (WDNR) Case Activity Number: 02-68-098404. The former Navistar facility (Site) is located at 1401 Perkins Avenue in Waukesha, Wisconsin. The Site remains active and the facility is currently operated by Renaissance Manufacturing Group (RMG) – Waukesha Foundry. RMG also owns the operations at the facility. Navistar remains the current property owner.

The initial investigation at the facility occurred in the late 1980s with subsequent investigations and regulatory reviews since that time (RMT 1993). Navistar completed a subsurface investigation at the Site in 2014 and issued a Site Investigation Report dated August 2015. The WDNR responded in a letter dated June 29, 2016, requesting additional subsurface investigations and completion of a vapor intrusion assessment on- and off-site. TRC completed a work plan to address the soil and groundwater component of WDNR's requests in advance of this vapor investigation (TRC 2016). WDNR responded by letter dated November 9, 2016 that the vapor intrusion investigation proceed in concert with the soil and groundwater investigation. A conference call between WDNR, Navistar, and TRC was held on December 15, 2016 to discuss agency comments and provide a path forward that led to preparation of this work plan.

The facility has been used for multiple metals fabrication operations some of which included the use of chlorinated organic compounds (CVOCs). The main constituents of concern at the Site were identified as chlorinated solvents; primarily trichloroethene (TCE) and 1,1,1-trichloroethane (TCA). Historical information notes that neighboring properties and possibly other offsite sources may have contributed to CVOCs detected in the groundwater.

## 1.2 Purpose and Scope

TRC, on behalf of Navistar, offers this work plan to conduct sampling for the purpose of investigating vapor intrusion potential at the former Navistar facility and surrounding properties, in accordance with WDNR guidance (WDNR 2014, WDNR 2015). 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 work plan. The purpose of this investigation 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.

The vapor intrusion investigation will begin with obtaining permission from property owners to access offsite properties, a site walk/assessment to finalize sampling details at these properties, followed by the initial vapor monitoring activities. Further investigative work, if needed, will be dependent on the initial sampling and analytical results.

# Section 2
# Site Conditions

A site description, geologic setting, hydrogeology, history of previous investigations for the Site, and recognized environmental conditions are summarized in this section to provide a framework for a site conceptual model for vapor migration.

## 2.1 Site Summary

### 2.1.1 Site Location

The approximately 14-acre site is located at 1401 Perkins Ave. in the City of Waukesha, Waukesha County, Wisconsin (SE ¼, SW ¼, Section 35, Township 7 North, Range 19 East).

### 2.1.2 Site Description

The Site is bordered on the west by Whiterock Avenue and on the east by Cleveland Avenue (Figure 1). The boundary to the south is Perkins Avenue. The Site is bordered to the north by the former Wisconsin Coach Lines (WCL) site (BRRTS #0368004354), the Dairyland Buses site (BRRTS #0368001343), and Niagara Street. A portion of the Navistar property, west of the former WCL building, was leased by WCL from Navistar for use in their bus transportation operations. The McGlenn property that includes the Tews Company (Former General Castings – BRRTS #0368004657), TBA Distributors (BRRTS #036800424), and the Former Roundhouse Site (BRRTS #0268168232) is located to the south/southwest of the Navistar property, south of Perkins Avenue and was developed with single family homes and duplexes after those contaminated properties were closed.

Land use surrounding the Site is a mixture of residential, commercial, and industrial. Commercial properties are primarily located to the west and east of the property with residential development to the north and south. A CN railway is located behind the commercial properties to the west, with Frame Park located between the railway and the Fox River. The river is located approximately 600 feet from the western Site boundary (Figure 1). An unnamed creek enters a culvert near the eastern Site boundary and is conveyed beneath the property and discharges to the Fox River in Frame Park. There are numerous other contaminated properties listed in the WDNR database located within the drainage area of this unnamed creek other than those listed above.

### 2.1.3 Facility Operations

International Harvester purchased the property from General Malleable Corporation in 1946 and operated as a malleable iron castings foundry. In 1986, International Harvester changed its name to Navistar International Corporation. Navistar operated the foundry under various names until May of 2015 when the facility was sold to RMG. RMG continues many of the same operations that were conducted under the ownership by Navistar.

### 2.1.4 Former Solvent Use Areas

Historical documents from project files compiled by Navistar and TRC reviewed in the course of preparation of the Supplemental Site Investigation Work Plan (TRC 2016). A solvent management plan was prepared by Navistar in 1991. The locations of machines, tanks and storage areas where solvents were previously located are shown in drawings included as Appendix A of the work plan (TRC 2016). These chlorinated solvents were phased out in 1993. The following summarizes the information in the solvent management plan:

- The facility used solvents containing mineral spirits (Safety-Kleen Solvent-MS) for parts washers at four locations within the facility with holding tanks: a truck maintenance area (60 gallon capacity), machine shop (30 gallon capacity), Building #4 and Building #7 maintenance areas (30 gallon capacity).
- The Core Wash area is located at the northwest corner of the facility. The core wash process used chlorinated solvents [primarily 1,1,1-trichloroethane (TCA)] stored in an open topped tank with a capacity of approximately 30 gallons. The material was shipped in 55-gallon drums stored in the West Yard with approximately 20 drums present at any one time.
- Petroleum distillates (Y-290 Liquid Parting) was used at five molding lines located along the north side of the facility. The material was sprayed under pressure to facilitate release of molding sand from a pattern. The liquid was supplied to the spray gun from four, 250-gallon totes, with four similar totes stored in the East Yard as reserves and "two or three 55-gallon drums stored in the barrel rack."
- Release Agent FR-4 also contains 1,1,1-TCA, and was sprayed onto the core machines to facilitate release of the core sand. One drum of this liquid was stored in the Core Room next to the Hormel scrubber with a second drum stored in the "West Yard Storage Area."

Soil borings were advanced in close proximity to each of these area in 1993 and low concentrations of CVOCs were detected in the shallow soil at each location (RMT 1993).

Groundwater samples collected from monitoring wells on the neighboring WCL site and later on the Site detected CVOCs in the groundwater.

## 2.2 Physiographical and Geological Setting

### 2.2.1 Site Topography

The Site is located at the base of sloping terrain to the north and south along an unnamed creek bed that is conveyed beneath the plant in a large-diameter storm drain. The Site slopes to the west and south, with surface elevations at the Site ranging from approximately 860 feet MSL at the northeast corner of the property to approximately 830 feet MSL at the southwest corner of the property (Figure 1). An active railroad corridor is present to the west of the Site. Drainage culverts are present on the northern and southern property boundaries along the roads. The unnamed creek empties into the Lower Barstow Impoundment of the Fox River at an elevation of approximately 810 feet MSL

### 2.2.2 Site Geology

The Site is underlain by unconsolidated deposits consisting of an unsorted mixture of clay, silt, sand, and gravel comprising glacial drift and fill that includes foundry sand, crushed stone and soil. The overburden varies in thickness from approximately 15 to 23 feet bgs, generally increasing in thickness to the west. The principal stratigraphic unit of the glacial drift is the New Berlin Formation. The New Berlin Formation is subdivided into upper and lower units. The upper unit is composed of gravely sandy loam till that extends to a depth of approximately 35 feet. Beneath this unit is a sand and gravel unit interpreted as outwash sediment. The entire sequence of basal till and sand and gravel lenses comprises the New Berlin Formation at the Site (Schneider, 1983). The New Berlin Formation overlies Silurian bedrock of the Niagara dolomite. The elevation of the top of bedrock decreases from approximately 819 MSL to 809 MSL from east to west across the Site. The Niagaran dolomite is approximately 200 feet in thickness in the Waukesha area (RMT 1999).

### 2.2.3 Site Hydrogeology

Groundwater is typically first encountered at depths ranging from 8 to 17 feet below ground surface (bgs). The groundwater elevations range from approximately 823 to 815 feet above mean sea level (MSL). Groundwater is typically encountered in the outwash deposits of the lower New Berlin Formation, however the bedrock surface is differentially weathered causing groundwater to also be first encountered within the dolomite bedrock. Shallow horizontal groundwater flow in the outwash and weathered dolomite beneath the Site is to the west towards the Fox River. The elevation of the Fox River is maintained by a dam in Frame Park at an approximate elevation of 810 feet MSL.

Deeper groundwater flow in the bedrock is along fractures and bedding surfaces that may result in localized preferential flowpaths, though the regional flow direction likely mimics the shallow system. The groundwater flow direction may be impacted by dewatering of the active Waukesha Lime and Stone East Quarry located approximately 4000 feet north of the facility, though the primary groundwater flow is to the west to the Fox River.

The principle sources of groundwater in eastern Waukesha County are the unconsolidated sand and gravel, the shallow Niagara dolomite, and the deep sandstone aquifer. According to WDNR water well records, the vast majority of groundwater used in the City of Waukesha is provided by the deep sandstone aquifer, although some private wells are screened in the Niagara dolomite and the unconsolidated sand and gravel. The sandstone aquifer is separated from the sand and gravel, and the Niagara aquifers, by the Maquoketa Shale which acts as a confining layer (Schneider, 1983).

# Section 3
# Vapor Intrusion Investigation

Navistar requested a vapor intrusion evaluation from TRC of the Site and surrounding properties as part of case closure efforts. An initial background review of the former Navistar facility and surrounding properties was completed and each property assessed based on former and current use. The vapor intrusion screening assessment was completed and is included as Appendix C. The screening assessment selected a number of properties adjacent to the Site as potentially requiring a vapor intrusion investigation based on proximity to impacted areas of the Site. The final number of properties chosen for the proposed vapor intrusion investigation will be based on the extent of the CVOC groundwater plume identified at the Site and potential preferential pathways (i.e. through buried utilities) where vapor intrusion may be present. Any subsequent vapor intrusion investigations will conducted in a stepwise fashion as more data are collected and interpreted and the conceptual model is revised.

## 3.1 Vapor Intrusion Evaluation

The WDNR (2010) 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 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 a vapor intrusion evaluation be completed for CVOC sites if any of following conditions exist on-site or off-site (Section B WDNR 2015):

- Any buildings overlying a CVOC soil source.
- Any buildings within 100 feet of a CVOC soil source.
- Any buildings overlying a CVOC groundwater plume located at the water table with groundwater concentrations above Wisconsin NR 140 groundwater enforcement standards (ES).

- CVOC contaminated groundwater above Wisconsin NR 140 groundwater preventive action limit (PAL) is entering a building or in contact with the building's foundation, or is in water intercepted by the building's foundation drain system, including sumps.
- CVOC vapors have the potential to enter preferential pathways (sewer lines, fractured bedrock, foundation cracks or openings, etc.) that connect contaminated areas to a building and migrate into that building.
- Vapor Intrusion Monitoring

Vapor intrusion investigations are completed by collecting various types of samples to assist in determining if a risk is present and if a vapor mitigation system 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.

#### 3.1.1 Sampling Types

A typical vapor intrusion assessment requires samples to be collected from sub-slab in buildings, indoor air, and 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 vapor intrusion has occurred 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 (2015) recommends that outdoor air samples should be collected when indoor air monitoring is completed.

In general, and as further discussed in Section 3.2.2, each property will be 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.

### 3.1.2 Sub-Slap Vapor Intrusion Monitoring

There are two types of vapor intrusion monitoring methods that may be utilized for the investigation of sub-slab vapors as they relate to this work plan. The methods are further outlined in Section 4 and Section 5 and are dependent on the type and use of the property being investigated. The two methods are: (1) discrete sampling and (2) modified soil venting assessment techniques (referred to in this document as "high purge vapor sampling").

The discrete sampling method is generally used in smaller facilities (small commercial and/or residential properties) and represent a more limited area. The commercial properties will generally include multiple discrete samples based on the overall square footage of the building, presence of impacted groundwater plume below the building, the layout of the building, and the types of operations that occur in the building. The selected number of samples is generally obtained following an on-site assessment of the property. The WDNR recommends three sample locations for buildings with a footprint of 5,000 square feet and an additional location for every additional 2,000 square feet (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 square feet (WDNR 2014).

High purge vapor sampling methods are generally used at larger industrial/commercial type facilities where discrete sampling would require an overabundance of sample ports. The high purge method utilizes an extraction blower to collect vapors from a larger area below the building slab and a sample is collected from the extracted vapors. During the high purge vapor sampling, a radius of influence calculation for each sample port can be estimated to better understand the areal vacuum coverage. These calculations are based on the observed purge rates and the depth and porosity of the fill material below the slab. Pressure field extension testing can also be conducted during the high purge sampling process to field test the radius of influence. For the larger industrial and commercial facilities, high purge sampling methods are used based on their footprint and property use.

In general, these properties only require one round of sub-slab monitoring to determine the degree and extents of vapors present. The number of samples and locations are based on the use and layout of the onsite buildings with respect to known soil and/or groundwater contamination along with the underlying geology.

### 3.1.3 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 a 24-hour period 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.

For commercial/industrial properties, indoor air samples may not always yield representative data, especially at properties where volatile materials are being used. In addition, larger commercial/industrial properties often have elaborate air exchange systems that would preclude accumulation of subsurface vapors. Due to these factors, understanding the sub-slab conditions is a crucial first step in understanding if the indoor air could be impacted at a commercial/industrial facility. If initial sub-slab vapor sampling indicates the potential presence of indoor air impacts, a surrogate test can be completed to better quantify the potential risks at the site. Such properties are benefitted by a surrogate test which can be used to directly measure the air exchange through the floor slab to the indoor air. In general, if the initial sub-slab investigation identifies a potential risk at these larger facilities, a radon surrogate test can be used to determine a building-specific attenuation factor between the sub-slab vapor and indoor air (further described in Section 3.5). The results of the sub-slab vapor monitoring and the surrogate test can then be used to determine if sub-slab vapor intrusion from the underlying impacted soil/groundwater is occurring at the investigative property.

## 3.2 Community Relations Plan, Property Access, and Property Assessments

Property access agreements and property assessments are integral to conducting a successful vapor intrusion investigation. Gaining site access will require assistance from a community relations expert and possibly include interaction with local government officials. A Community Relations Plan (CRP) will be prepared to explain the process by which site-related information will be provided to the community in a formal and coordinated manner. The plan will be tailored to address risk to the community as a whole and to the individuals whose properties may be adversely affected. The plan will outline the process to find consensus among responsible the project team, WDNR, and other authorities on appropriate levels of outreach, and thoroughly document outreach activities. The plan for the Navistar site is especially complex because of the multiple media affected and the transport mechanisms involved. The information provided to stakeholders must be simplified so that community members without specialized knowledge can understand what to expect regarding communication, investigation, risk, mitigation, and remediation. The CRP will also identify sources of technical assistance for concerned citizens and explain how stakeholders can obtain answers to technical questions.

Ensuring that the community has essential information and access to technical resources will allow community members to develop the understanding needed to make informed decisions related to their personal risk.

### 3.2.1 Property Access Agreements

Prior to any initial onsite assessments or the collection of vapor samples, the property owners will be notified and informed about the proposed investigation. TRC will work with a community relations consultant to craft access agreements for each property. These agreements will then be distributed and likely have to be explained and negotiated with the property owners. TRC and the community relations consultant will then arrange a time that the buildings can be entered. Sampling within the structures will only proceed for those properties where an access agreement can be obtained.

### 3.2.2 Residential Property Assessments

Residential properties typically do not require an initial on-site assessment because of their small size and general simplicity of use and construction. However, each residence will be assessed to identify the type of basement flooring and slab, the condition of the slab, presence of sumps or drains, visual or olfactory evidence of groundwater intrusion, excessive use of solvents, etc. These conditions will be recorded on field data sheets and photographs taken as necessary. A further discussion of the initial assessment and sampling is given in Section 5.1. Duplexes that share a common basement will initially be assessed as a single residence. The need for sampling the second dwelling of the duplex will be assessed on a case-by-case basis.

### 3.2.3 Commercial/Industrial Property Assessments

Prior to performing any vapor intrusion sampling activities at the former Navistar facility and surrounding properties, an assessment/focused site walk of the nearby commercial and industrial properties is necessary to determine the proper method and number of samples at each property. TRC will evaluate the layout and square footage of each facility and document various conditions (i.e. HVAC system, building layout, concrete slab condition, property use, etc.).

## 3.3 Proposed Properties for Initial Vapor Intrusion Assessment

The buildings listed below have been selected for an initial vapor intrusion assessment as discussed in the vapor intrusion screening assessment (Appendix C). Figure 2 illustrates the location of each property with respect to the Site. 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 the CVOC impacts are further delineated.

- RMG Waukesha Foundry (the western third of the facility overlying impacted groundwater and/or impacted soil as previously delineated);
- The Interstate Pump and Tank (IPT) facility located at 901 Niagara Street (north of the Site);
- Four commercial properties to the west-northwest of the Site, along Whiterock Avenue; and
- 14 residential properties to the north, south, and west of the Site

TRC's initial assessment has identified the western third of the RMG buildings, the IPT property north of the site, and possibly one of the four commercial properties along Whiterock Avenue to be assessed for vapor intrusion through high purge vapor monitoring methods. Portions of these properties may contain small non-industrial use buildings where discrete sampling may be also necessary. The smaller commercial and residential buildings are anticipated to be assessed using discrete sample locations. In keeping with WDNR (2010) 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 will assessed as part of the data analysis of the vapor intrusion investigation described in this work plan. Figure 2 shows the buildings that will be included in this assessment and the estimated number of samples to be collected at each building.

## 3.4 Radon Surrogate Test

In addition to the sub-slab VOC monitoring, TRC may complete radon surrogate tests in order to calculate site-specific attenuation factors for each property where indoor air sampling is not applicable. Site-specific attenuation factors are a function of slab thickness and physical condition of the slab. This test is useful because the default attenuation factor (0.01) for larger commercial/industrial facilities used by the WDNR is overly conservative for most floor slabs, and leads to an overestimate of the risk of vapor intrusion. For this test, radon (a naturally occurring soil gas) is measured directly in the sub-slab vapor and in the indoor air to calculate the site-specific sub-slab vapor to indoor air attenuation factor. This calculated attenuation factor is then applied to sub-slab VOC vapor concentrations to estimate VOC concentrations in indoor air that result from movement through the foundation and into the building. This approach was documented by McHugh, (2008), and subsequently pioneered by TRC in Wisconsin, receiving approval by WDNR at multiple sites. The test will only be completed in commercial/industrial properties if the initial sub-slab vapor intrusion assessment concludes that elevated concentrations of constituents of concern are present.

### 3.4.1 Radon Measurement Instrument

Numerous types of instruments and approaches are available to measure radon concentrations. For this application, the Durridge RAD7 continuous radon monitor will be used to measure radon levels. This instrument is preferred because it pumps vapor directly from below the slab, is not susceptible to interference from moisture, and can provide accurate measurements of radon over a wide range in concentrations within a reasonable time frame (hours as opposed to weeks).

### 3.4.2 Radon Background and Indoor Air Sampling

TRC will measure a background concentration for radon outside near buildings where the surrogate test is being completed. This will be completed prior to initiating sub-slab and indoor air sampling for radon. The site background concentration will be subtracted from indoor air and sub-slab concentrations measured at the site for attenuation calculation purposes. The background radon concentrations will be measured and recorded every 10 to 15 minutes for a two- to four-hour duration.

The indoor air within the facilities will be monitored for radon for 8-12 hours, and measurements will be recorded every 30 minutes. The number of monitors will be dependent on the layout and size of the property being investigated. Eight to twelve hours is an approximate time and has been selected based on previous experience with these meters for representative information. The indoor air measurements will be taken at approximately 4 to 5 feet above the floor.

### 3.4.3 Radon Sub-slab Vapor Sample Points

Radon sub-slab sample probes will be installed at the facilities where indoor air monitoring cannot be conducted, in the quantities described in Table 1 below. The approximate number of collection point locations is estimated based on publicly available aerial photographs and will be refined based on the site walk and the layout of each facility. The sub-slab vapor probes will be installed using Cox-Colvin® Vapor Pins® in accordance with the manufacturer's standard operating procedures or using the previously installed high purge sample ports. The advantage to using the Cox-Colvin® Vapor Pin® is the ability to install flush mount ports which only restrict facility operations while sampling is being conducted. Following sampling at these locations, the ports will be capped, and normal facility operations can proceed.

The number of sub-slab, indoor air, and background radon monitoring points planned for each facility are described in Table 1.

Table 1
Facility-Specific Sampling Plans for Radon Surrogate Testing

| | SUB-SLAB RADON MONITORING | INDOOR AIR RADON MONITORING | BACKGROUND RADON MONITORING |
|---|---|---|---|
| IPT facility (1 building) | ≤ 8 locations | 4 locations | 1 event |
| RMG Waukesha Foundry (up to eight buildings) | ≤ 10 locations | 4 locations | 1 event |
| Commercial Properties (four buildings) | 2-4 locations each | 1-2 locations each | 1 event per day of indoor air and sub-slab monitoring |

# Section 4
# High Purge (Integrated) Sub-slab Vapor Monitoring

TRC proposes to collect sub-slab vapor samples using high purge sampling (WDNR 2015 and McAlary 2010) at the larger-sized facilities included in this investigation, that includes the RMG facility, the IPT facility, and possibly (pending a site walk/assessment) one of the four commercial facilities located northwest of the Site (Figure 2). There is potential that portions of these properties may contain small non-industrial use buildings where discrete sampling may be more applicable, as such multiple sampling methods may be used to assess each property.

## 4.1 Personal Protective Equipment

TRC will wear personnel protective equipment (PPE) as required by TRC policies and property-specific health and safety requirements. PPE required by TRC will consist of Level D protection and will depend on the tasks being completed. In general TRC personnel will wear reflective vests, eye protection, and steel-toed boots. Hearing protection, hand protection as needed (i.e. Kevlar and nitrile gloves), dust/particle masks, and hard hats will be worn as needed depending on the task being completed. A list of the necessary equipment will be provided in the onsite health and safety plan prepared by TRC. In addition, all TRC personnel will comply with any necessary safety training required by the individual facilities.

## 4.2 Proposed High Purge Sub-slab Vapor Sampling Points

As previously discussed in Section 3.3.2, an initial assessment/focused site walk will be conducted at each industrial and commercial property to identify potential sample locations and determine the sample methods and final number of samples required for the investigation. Based on current Site information the approximate number of high purge sub-slab vapor points proposed for the RMG facility and adjacent IPT property, are 10 and 8, respectively. There are four commercial properties to the west of the foundry which contain buildings with approximate foot prints ranging between 2000 and 16,000 square feet. The largest commercial property is anticipated to require up to four high purge sample locations. The remaining three commercial properties are anticipated to be investigated using discrete sampling methods and are further discussed in Section 5 of this work plan.

The high purge sampling points will be located to characterize the vapor intrusion risk. The sampling points will be located approximately 25 feet from the edge of exterior walls to minimize the potential that soil gas from outside the building footprint is incorporated into the samples. In addition, sample spacing will be dependent on the layout of the facility and ensuring sufficient samples are collected to obtain representative results for each property. To ensure representative results and sufficient sample density/areal vacuum coverage, pressure field extension testing will be completed during the high purge sampling process and an estimated radius of influence will be calculated using the estimated purge flow rate and assumed thickness and porosity of the fill material below the slab of the facility. Final locations will depend on available access, and will be cleared by and approved by the property owners to avoid underground utilities and impedance on normal site operations.

## 4.3 High Purge Sampling Point Construction

Each high purge sampling point will be inserted into a 1.5- to 2-inch diameter hole drilled through the concrete floor slab. The hole is drilled using a hammer drill and masonry bit and extends approximately 6 to 8 inches below the floor slab into the granular fill material. TRC will use a vacuum with a high-efficiency particulate arrestance (HEPA) filter during all drilling work as a dust control measure. A 0.75-inch–diameter PVC pipe with a machine-slotted screen will be set in the fill, and a 0.75-inch–diameter PVC riser pipe will extend approximately 4 to 6 inches above grade to be connected to an extraction blower. Clean sand will be placed around the well screen to fill the annulus to the bottom of the slab, and concrete grout will be used to provide a protective seal between the slab and the riser pipe. The concrete grout will be allowed to set and dry for a minimum of 12 hours or per the manufactures recommended cure time prior to pulling a vacuum from each point. Each riser pipe will be capped when not being used for sampling, to eliminate the potential to draw indoor air into samples being collected at adjacent sampling points. The completed vapor sampling ports will be left in place until all vapor sampling required for the property has been completed and assessed. Since the ports will be left in place for an extended period, TRC will work with each property owner to ensure port locations do not impede on their everyday operations.

## 4.4 High Purge (Integrated) Sample Collection Method

The high purge sampling approach collects an integrated sample of the sub-slab air from the void space in the granular fill immediately under the concrete slab. This integrated approach allows for the characterization of the sub-slab air over a larger area that is more representative of the exposure in the building, rather than using a discrete point sampling approach which is less representative of the actual exposure area and more sensitive to local biases.

TRC's procedure for collecting the integrated sample is as follows:

- A sealed blower is used to draw a vacuum from each sampling point, and each point will be sampled individually. The blower is fitted with a sampling apparatus on the discharge to allow for sampling and monitoring of the extracted vapors. Extracted vapors pass through this apparatus and discharge into a hose extended to the exterior of the building.

- A leak test (shut-in test) prior to the collection of each sample will be completed to test the SUMMA® canister and associated connections 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.
- Prior to sampling, the blower will be turned on, and sampling point will be purged for approximately 5 minutes.
- During the purging process a smoke test will be completed while the blower is pulling a vacuum from each sampling point to look for potential leaks in the surrounding slab or in the sampling point components through which indoor air could be drawn into the sample. If a leak is detected, the purging will be discontinued and action will be taken to seal the leak, if possible. Once seals are applied, the process is repeated to ensure no leaks remain. The smoke test will also be completed periodically during sampling to ensure no additional leaks are created or found during this process. If a leak is identified during sampling, a new sample will collected once the location of the leak has been sealed.
- After purging is complete, the extracted vapors are collected in an evacuated 6-liter SUMMA® canister. Each SUMMA® canister will have a 30-minute regulator set on the intake, such that the sample will be collected over 30 consecutive minutes while the blower is operating on each sampling point.
- Each SUMMA® canister will be analyzed for a full VOC list using method TO-15.
- The airflow rate and vacuum that can be achieved at each sampling point will be monitored in the field and documented on a field sampling form (Appendix B). This data along with the assumed fill thickness and the estimated porosity of the fill material below the slab will be used to calculate an approximate radius of influence for each sample port to confirm areal vacuum coverage.
- Pressure field extension testing will be completed at select distance from each sample port during high purge sampling to field determine the areal vacuum coverage.

## 4.5 PID Screening

TRC will continuously monitor and electronically log the extracted vapor VOC concentrations from each sampling location using a MiniRAE 3000 Photoionization Detector (PID). The PID readings will be recorded every minute during the purging process and every two minutes during the sampling process over the approximate 35 minutes of operation of the blower. The continuous logging will assist is providing a conceptual understanding of the distribution of VOCs in the sub-slab air within the radius of influence of the sample. Stable PID readings indicate similar VOC concentrations are present throughout the sub-slab, whereas a spike in the PID readings may indicate a discrete area within the sub-slab has elevated VOC vapor concentrations.

## 4.6 Analytical Method

The samples collected by TRC will be properly packaged and shipped to PACE Analytical Laboratory in Minneapolis, MN or equivalent and analyzed using gas chromatography/mass spectrometry for VOCs as per  EPA Method Toxic Organics (TO)-15 analysis.

# Section 5
# Residential/Small Commercial Sampling

Sub-slab sampling using Cox-Colvin® Vapor Pins® (Vapor Pins®) are proposed to be conducted at 14 residences located near the RMG Waukesha Foundry, as indicated in Figure 2. One sub-slab sample point will be constructed through the concrete slab of the lower level of each residence. In addition, select commercial properties where high purge sampling may not be required will use similar methods to the residential monitoring with multiple Vapor Pins® installed to assess a larger area. It is anticipated that three of the four commercial properties will require between two and four sample locations per property depending on the layout and footprint of the building which will be determined during an initial assessment/focused site walk. The sampling methods outlined in this work plan will be completed per guidance provided but the WDNR (2014, 2015)

## 5.1 Access and Preparation

Once an access agreement is in place, the residential property owners (and resident, if different) or small commercial property owners (and occupant, if different), will be provided a list of items that may contribute to VOCs in the indoor air, and ask that they be removed from the building to the extent practicable, at least 24 hours prior to sampling. For the small commercial buildings where the radon surrogate test is completed, removal of these items may not be warranted. In addition, each resident will be requested to close all windows at least 24 hours prior to sampling. A visual survey of the sample area will be conducted and documented in field note sheets (Appendix B) to determine if items contributing to VOCs in the indoor air are present prior to sampling.

## 5.2 Indoor Air/Background Sampling

One indoor air sample will be collected from the basement of each residence prior to the installation of the sub-slab sample point. Each 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 VOCs. Site visits at the residences will be completed during the installation of the indoor air sample.

In concurrence with indoor air monitoring, a background ambient air sample will be collected near the properties being investigated which will provide additional information in reference to air quality surrounding the buildings (Section C WDNR 2015). Background samples will only be collected when indoor air monitoring is being completed.

If Vapor Pins® are used for commercial building assessment and indoor air samples cannot be collected due to onsite operations that might include use of organic solvents, the radon surrogate test will be completed as outlined in Section 3.5.

## 5.3 Sub-slab Sampling

### 5.3.1 Sample Point Construction

One sub-slab sample point will be drilled using a hammer drill and constructed through the floor of the lower level of each residence. TRC will use a vacuum with a HEPA filter during all drilling work as a dust control measure. Each sample point will be constructed using a Vapor Pin®. The Vapor Pins® will be installed according the manufacture's Standard Operating Procedure (SOP) (Appendix A). The Vapor Pins® will be constructed as flush mount points when possible and left in place following sampling pending the results of the vapor sampling. For commercial properties where high purge methods are not necessary, Vapor Pins® will be installed throughout the facility based on use, layout, and square footage. All Vapor Pins® 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.

#### *Leak Testing*

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 remains in place and no draining is visually observed the port has been sealed appropriately. An SOP for the water dam test provided by Vapor Pin® 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*

The tubing/sample train connections between the Vapor Pin® and SUMMA® Canister will be tested for leaks using a vacuum shut-in test, as described previously.

For either of the tests, if a leak is detected, corrective action will be taken to eliminate the leak prior to initiating collection of the sample.

### 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 VOCs.

# 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 report that will be transmitted to Navistar and the WDNR, along with recommendations for the next course of action to be taken at the Site. The analytical data along with calculated results from the radon surrogate test 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 May 2016 USEPA Regional Screening Levels Tables will be used for evaluation. 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 Navistar:

- There is no vapor intrusion risk.
  - If results indicate no vapor intrusion risk in a first sampling round and results represent sufficient areal vacuum coverage (i.e. all analytical results are below the screening levels and radius of influence calculation for high purge sampling indicate areal vacuum coverage), additional confirmation rounds of sub-slab vapor sampling will be recommended but will be property specific. For larger commercial/industrial properties where high purge vapor monitoring is completed, one sub-slab monitoring event may be sufficient. This assumes field data from pressure field extension testing and/or calculated radius of influences show good areal vacuum coverage. For smaller commercial and residential, up to three sampling events may be required. One of the sampling events must be completed during conservative conditions, if the initial sampling was not conducted under conservative conditions. 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 at the Site, and the limits of the area posing a risk have been defined.
  - In larger commercial/industrial properties where high purge vapor sampling was completed and results indicate a potential for vapor intrusion per the WDNR established screening levels, a radon surrogate test will be recommended. The

surrogate test can be used to determine if the current property conditions, are mitigating vapors and eliminating any risk.

   - For smaller commercial and residential properties where the initial investigation determines a risk of vapor intrusion, TRC will discuss with Navistar 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. during high purge vapor sampling sufficient areal vacuum coverage is not obtained and/or additional properties require investigation based on analytical results).
   - Develop a work plan for additional vapor sampling.
   - Develop a vapor mitigation or remediation plan based on the outcome of the additional sampling.

# Section 7
# References

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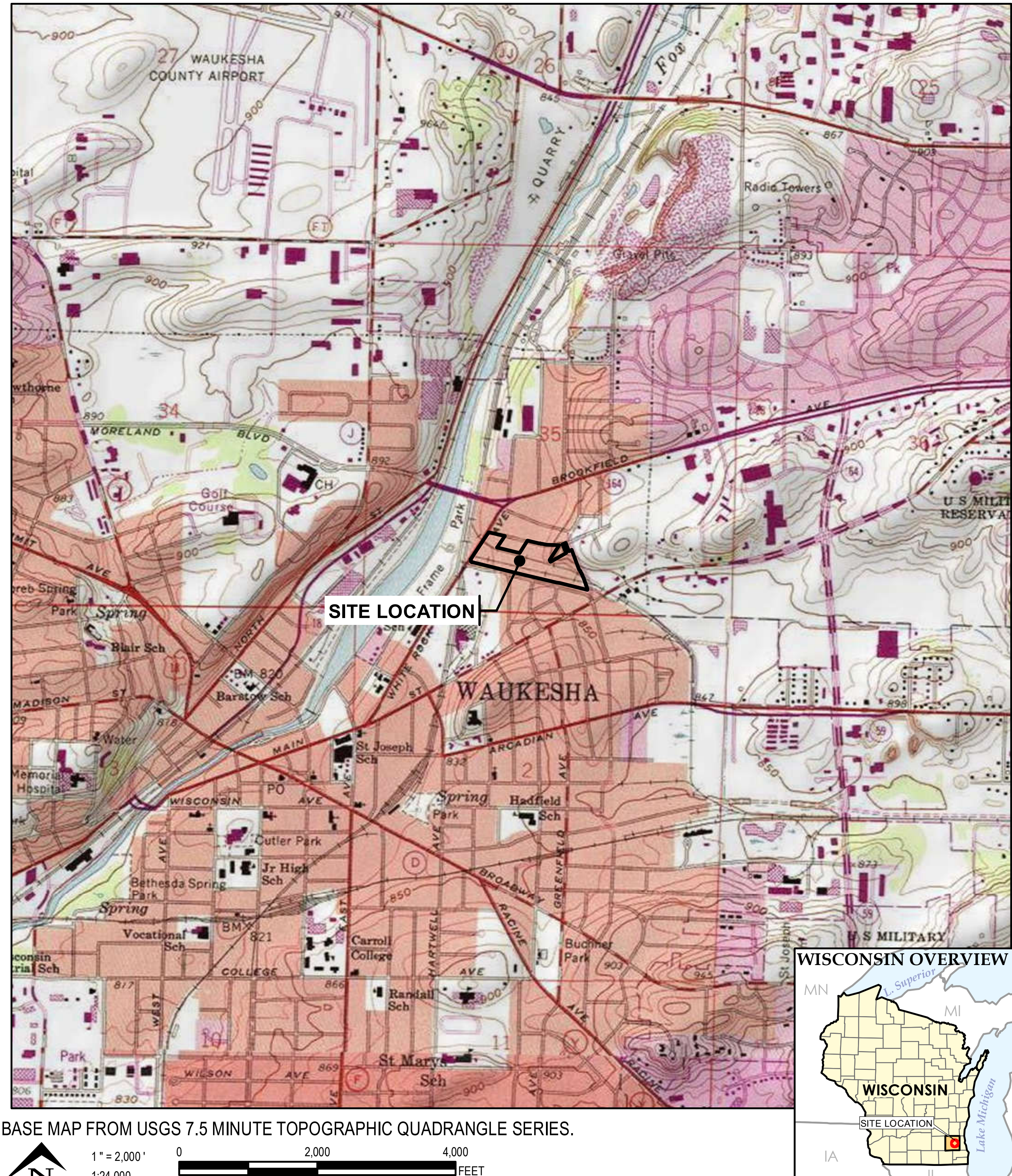


BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

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

0 2,000 4,000 FEET

TRC

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Suite 3000
Madison, WI 53717
Phone: 608.826.3600

TRC - GIS

PROJECT:

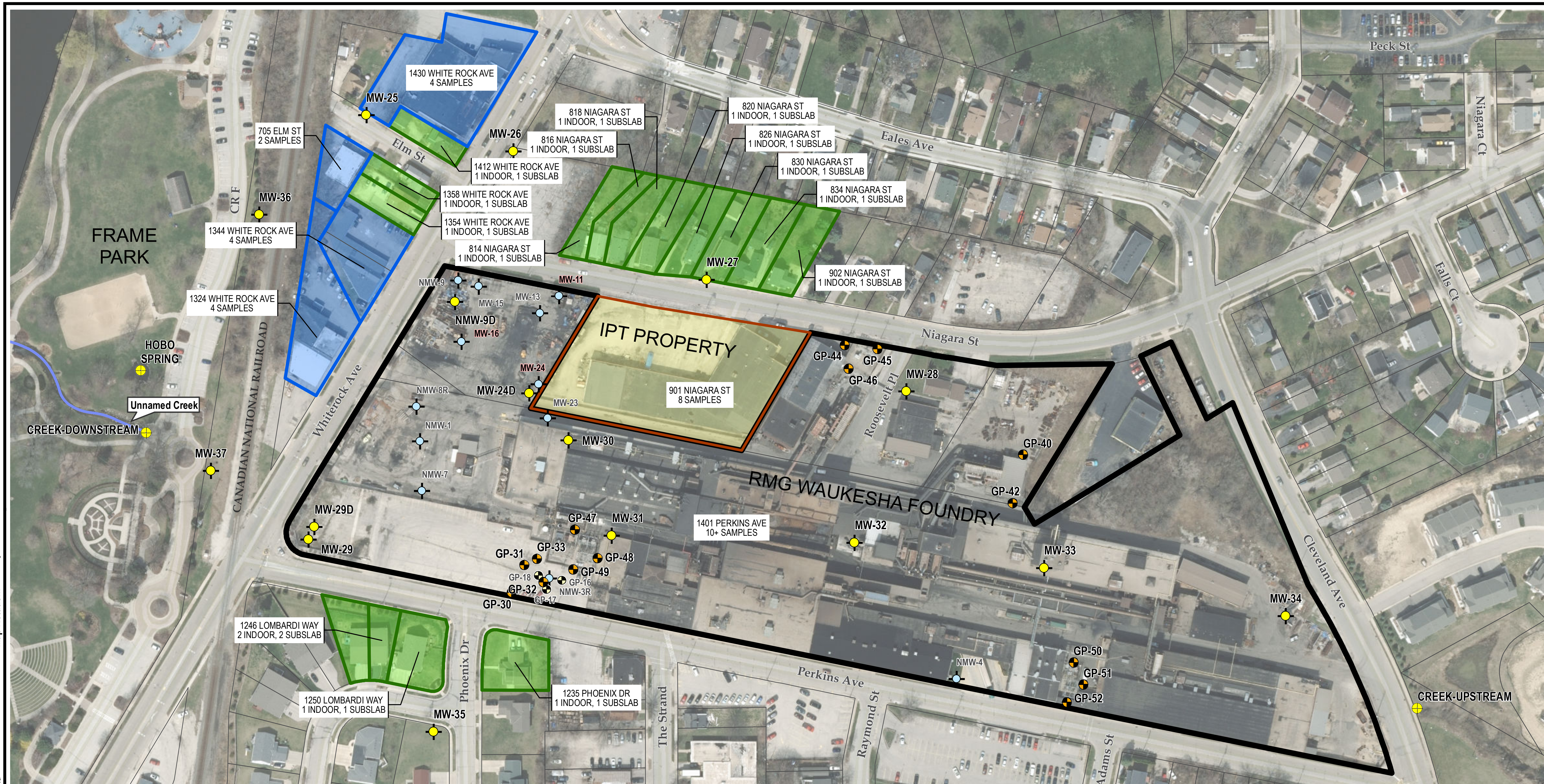
**FORMER NAVISTAR FACILITY**
**WAUKESHA, WISCONSIN**

TITLE:

**SITE LOCATION MAP**

| | |
|---|---|
| DRAWN BY: | PAPEZ J |
| CHECKED BY: | J WEDEKIND |
| APPROVED BY: | B HARMS |
| DATE: | JANUARY 2017 |
| PROJ. NO.: | 264084 |
| FILE: | 264084-001slm.mxd |

**FIGURE 1**




TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet (Foot US)
Map Rotation: 0

Plot Date: 5/11/2017, 10:05:25 AM by RSUEMNICHT -- LAYOUT: ANSI B(11"x17")
Path: E:\NavistarPurePower\2017_264084\264084-002.mxd

## LEGEND

- PROPERTY BOUNDARY
- MONITORING WELL LOCATION
- SOIL BORING
- MW-16 WELLS TO BE REPAIRED/ABANDONED
- PROPOSED MONITORING WELL
- PROPOSED SOIL BORING
- PROPOSED SURFACE WATER SAMPLE

TARGETED OFFSITE VAPOR SAMPLING

- COMMERCIAL PROPERTY
- INDUSTRIAL PROPERTY
- RESIDENTIAL PROPERTY

## NOTES

1. BASE MAP IMAGERY FROM WAUKESHA COUNTY, 2015.
2. PROPOSED WELL LOCATIONS DEPICTED HERE ARE APPROXIMATE. ACTUAL LOCATIONS WILL BE DETERMINED IN THE FIELD BY THE TRC ON-SITE GEOLOGIST.
3. THE INITIAL VAPOR INTRUSION INVESTIGATION WITHIN THE RMG FOUNDRY (1401 PERKINS AVE.) WILL BE FOCUSED TO THE WESTERN THIRD OF THE PROPERTY.

N

0 150 300 Feet
1 " = 150 '
1:1,800

PROJECT:
FORMER NAVISTAR FACILITY
WAUKESHA, WISCONSIN

TITLE:
SITE LAYOUT
PROPOSED SAMPLING LOCATIONS

| | | | |
|---|---|---|---|
| DRAWN BY: | J PAPEZ | PROJ NO.: | 264084 |
| CHECKED BY: | J WEDEKIND | FIGURE 2 | |
| APPROVED BY: | B HARMS | | |
| DATE: | MAY 2017 | | |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FILE NO.: 264084-002.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 | | | |
| [signature] | | [signature] | |
| Technical Reviewer<br>Stacy Metz | Date<br>7/28/16 | ECR Practice Quality Coordinator<br>Elizabeth Denly | Date<br>7/28/16 |

## TABLE OF CONTENTS

**Page No.**

## 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:
$\eta$ = 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.

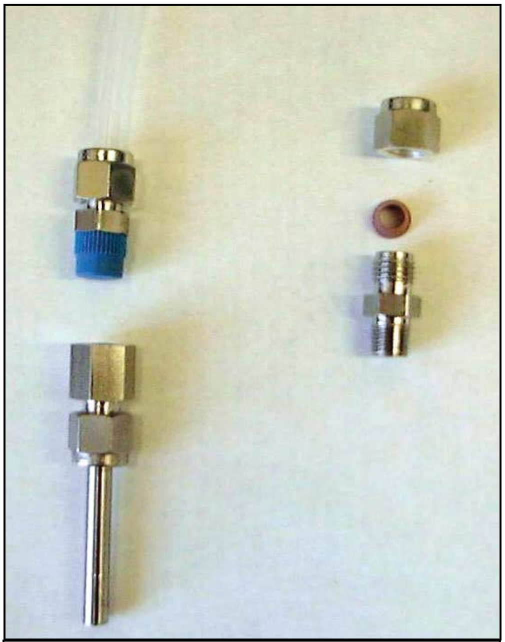
USEPA, 2015. OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, EPA OSWER Publication 9200.2-154. June 2015.

## 7.0 SOP REVISION HISTORY

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

# Attachment A: Photographs

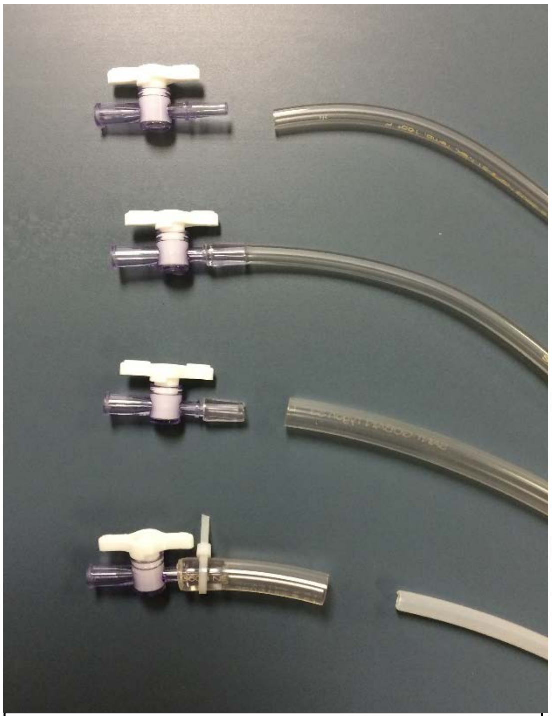
**Photograph 1 - Overhead view of completed point via Flush-mount Well Cover Method**



**Photograph 2 - Stainless-steel Probe Method components**

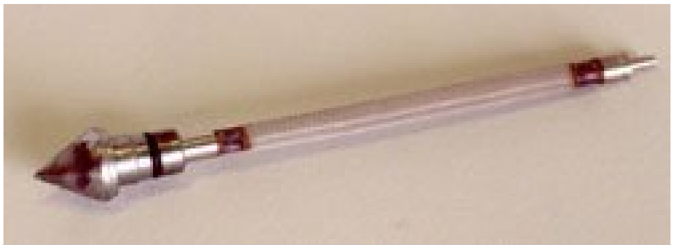
**Photograph 3 – Rotary hammer drill**

**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**

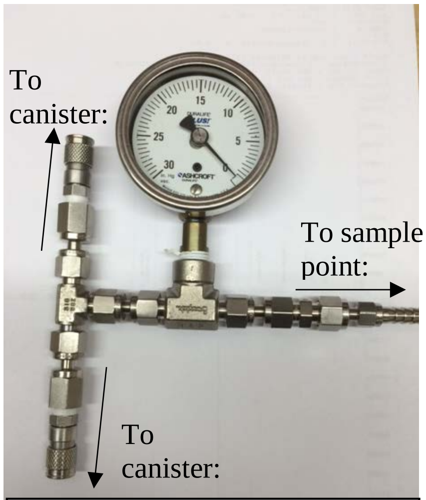
**Photograph 9 – Inline moisture filter and stopcock assembly (See Photograph 13, Item [C])**

**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.**

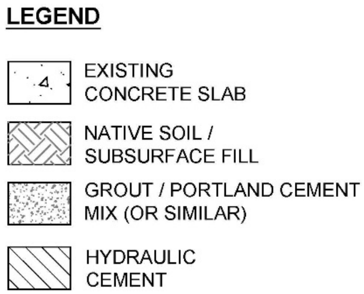
**Photograph 20 – Soil gas sample collection set up at deep soil gas vapor point with shroud to contain 1,1-difluoroethane tracer during sample collection.**

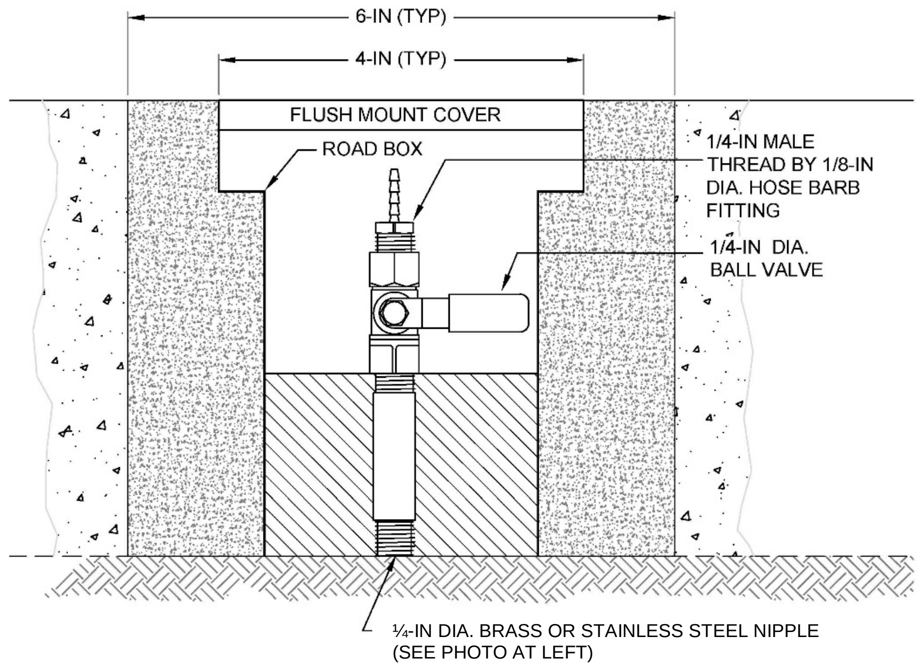
**Photograph 21 - Plastic wrap leak detection method during sampling**

**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



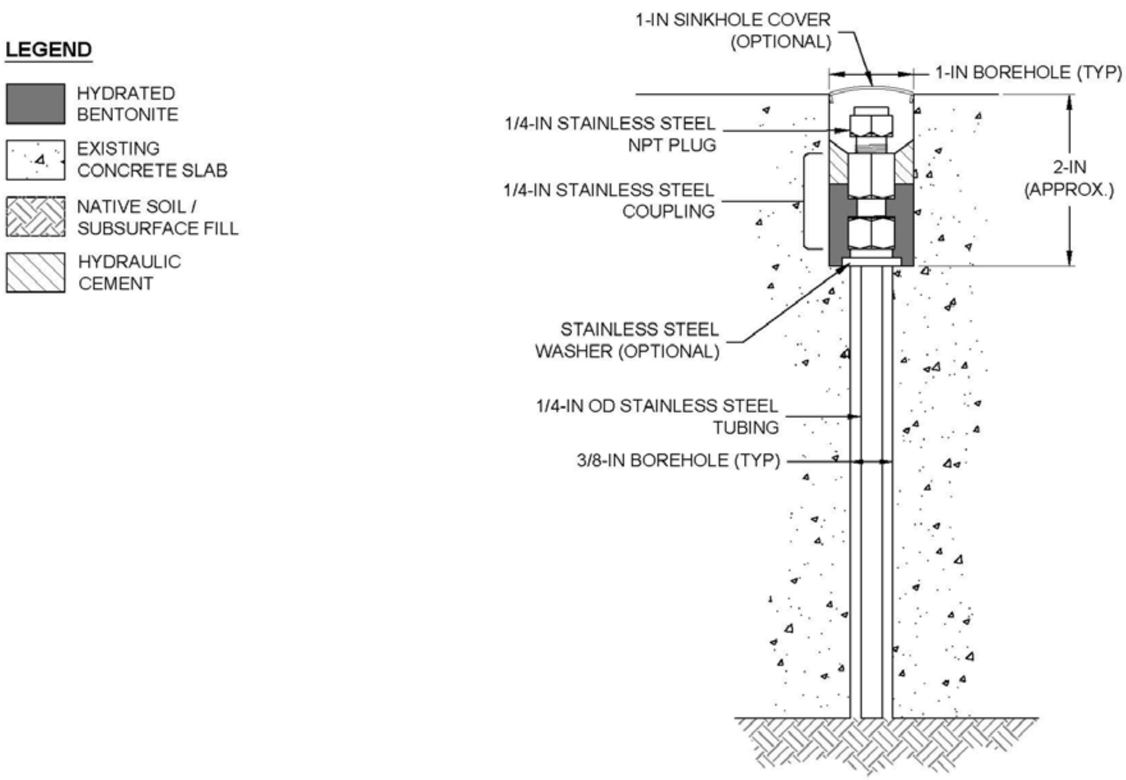




**Assembled Sample Point**
**Prior to Installation**

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

**Figure B-1**

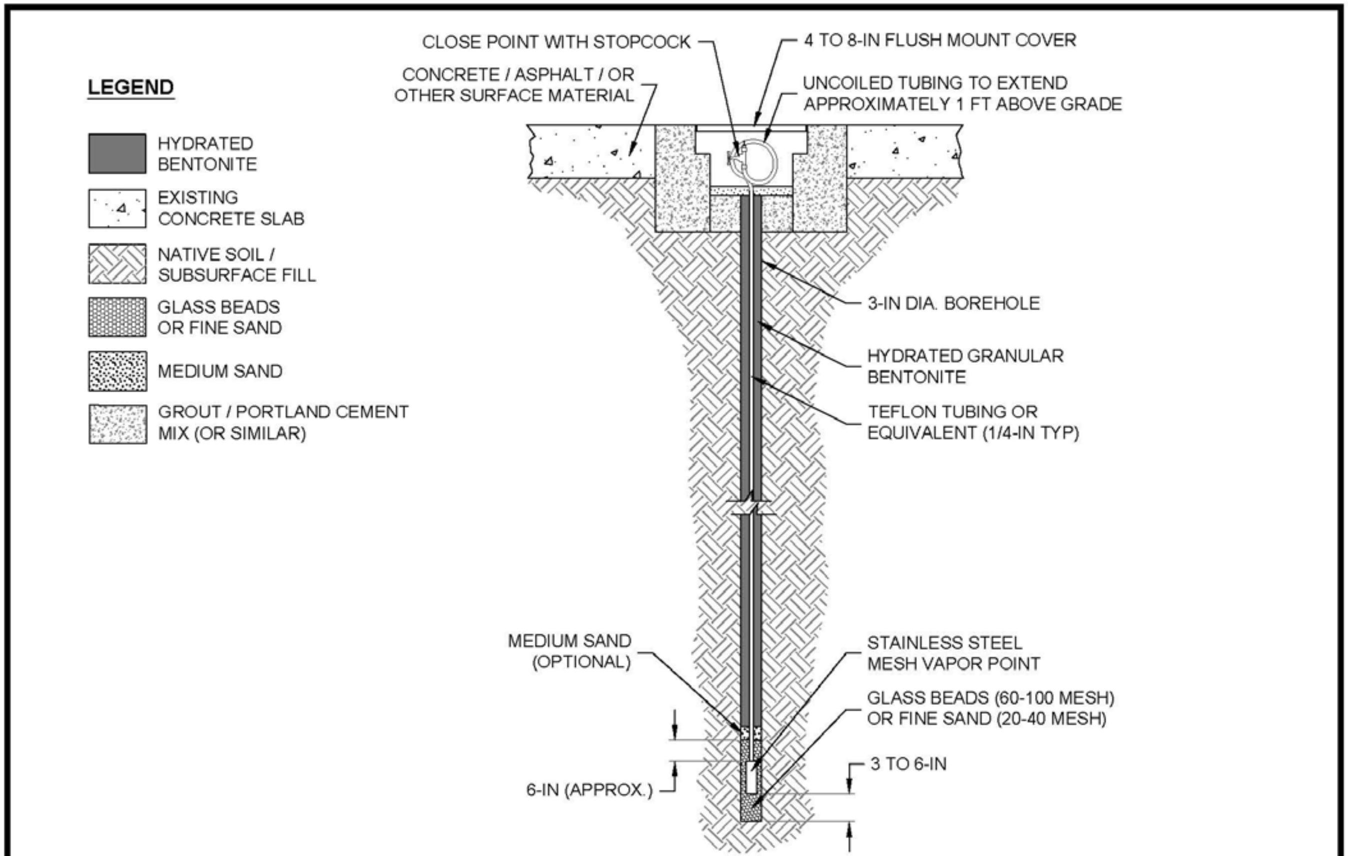
J:\PM SMetz_Soil Gas SOP\SG SOP Figs.dwg




**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

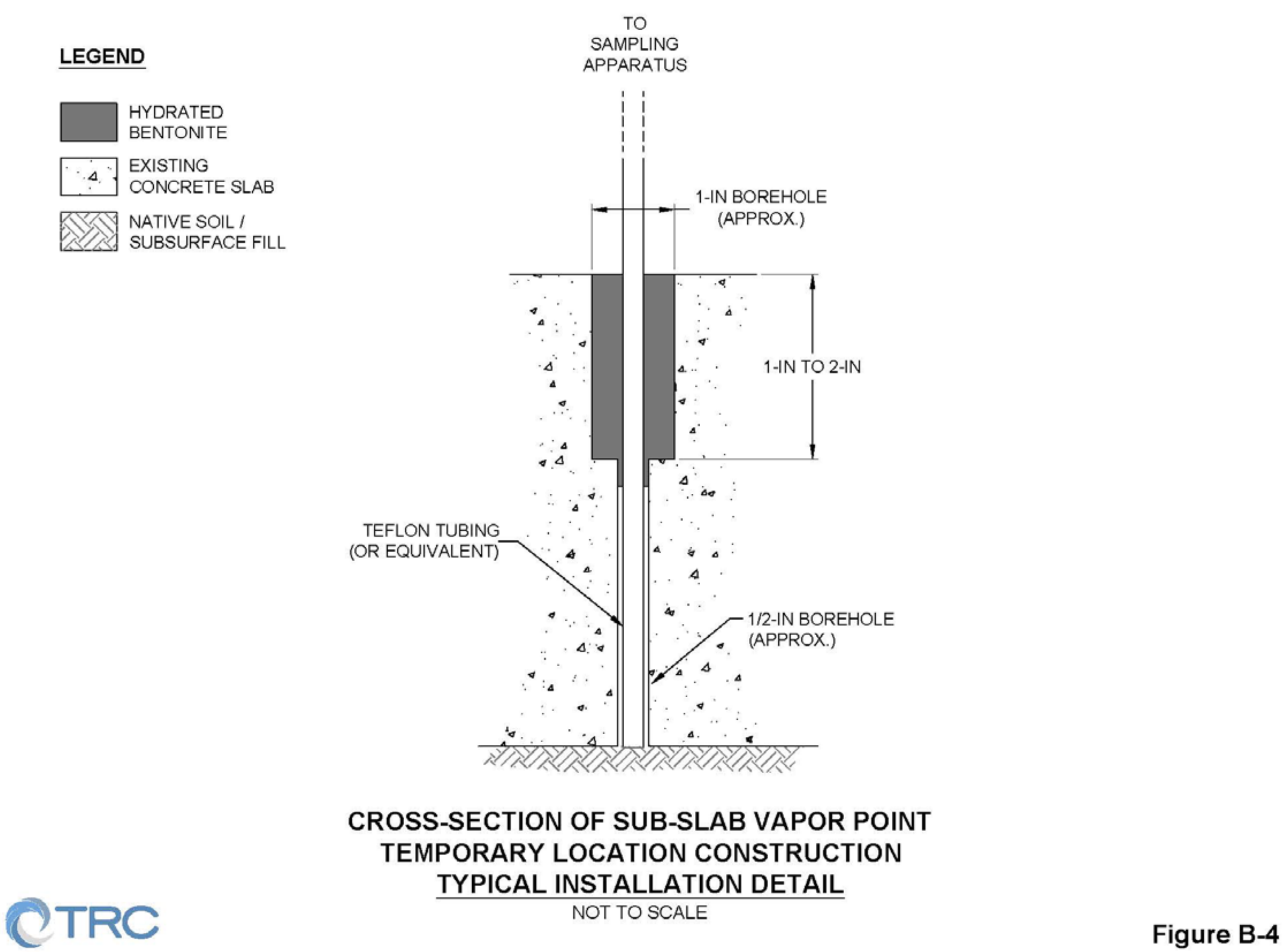



Figure B-4

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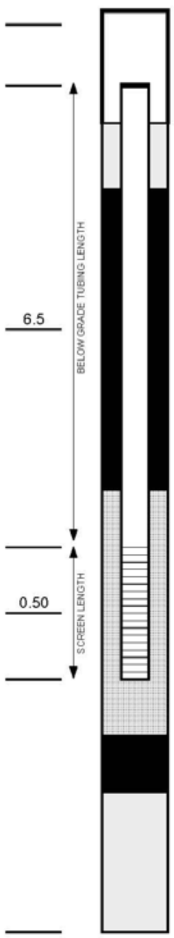
# Attachment C:
# Soil Vapor Point Installation and Sampling Field Forms

## 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 CM³ = 1 ML) OR TO CONVERT IN³ 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.

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:** | Navistar Waukesha Foundry |
| **PROJECT NUMBER:** | 264084.00 |
| **PROJECT MANAGER:** | Brian Harms |
| **SITE LOCATION:** | 1401 Perkins Avenue |
| **DATES OF FIELDWORK:** | |
| **PURPOSE OF FIELDWORK:** | Vapor Intrusion Monitoring |
| **WORK PERFORMED BY:** | A.Stehn |

SIGNED DATE CHECKED BY DATE

# GENERAL NOTES

| PROJECT NAME: Navistar Waukesha Foundry | DATE: | TIME ARRIVED: |
|---|---|---|
| PROJECT NUMBER: 264084.00 | AUTHOR: | TIME LEFT: |

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

| WORK / SAMPLING PERFORMED |
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| PROBLEMS ENCOUNTERED | CORRECTIVE ACTION TAKEN |
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| COMMUNICATION | | |
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SIGNED ______________________ DATE

CHECKED BY ______________________ DATE

REVISED 03/2008

# PID FIELD CALIBRATION LOG

| | | | |
|---|---|---|---|
| PROJECT NAME: | Navistar Waukesha Foundry | MODEL: | |
| PROJECT NUMBER.: | 264084.00 | LAMP VOLTAGE: | |
| SAMPLER NAME: | A.Stehn | SERIAL NO.: | |

## PID CALIBRATION CHECK

| | DATE:<br>TIME:<br>INITIALS: | DATE:<br>TIME:<br>INITIALS: | DATE:<br>TIME:<br>INITIALS: | DATE:<br>TIME:<br>INITIALS: | DATE:<br>TIME:<br>INITIALS: |
|---|---|---|---|---|---|
| BATTERY CHECK | ☐ | ☐ | ☐ | ☐ | ☐ |
| ZERO GAS | / | / | / | / | / |
| SPAN GAS | / | / | / | / | / |
| AUDIBLE FAN MOTOR CHECK | ☐ | ☐ | ☐ | ☐ | ☐ |
| RESPONSE CHECK | ☐ | ☐ | ☐ | ☐ | ☐ |

| NOTES |
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| PROBLEMS ENCOUNTERED | CORRECTIVE ACTION |
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SIGNED DATE

CHECKED DATE

TRC

# AIR / VAPOR SAMPLE LOG

| PROJECT NAME: Navistar Waukesha Foundry | PREPARED | | CHECKED | |
|---|---|---|---|---|
| PROJECT NUMBER: 264084.00 | 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:

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: ____________________ |

# HIGH PURGE SAMPLING LOG

***(to be used in concurrence with Air/Vapor Sample Log)***

| | |
|---|---|
| PROJECT NAME: Navistar Waukesha Foundry | DATE: |
| PROJECT NUMBER: 264084.00 | AUTHOR: |

| INITIAL PURGE | | | SAMPLING | | |
|---|---|---|---|---|---|
| **Start Time** | **Stop Time** | Duration | **Start Time** | **Stop Time** | Duration |

***PID Monitoring (ppm)*** (Initial Purge)

| | |
|---|---|
| Initial | |
| 30 Seconds | |
| 1 Minute | |
| 2 Minute | |
| 3 Minute | |
| 4 Minute | |
| 5 Minute | |
| 6 Minute | |
| 7 Minute | |
| 8 Minute | |
| 9 Minute | |
| 10 Minute | |

Comments:

***PID Monitoring (ppm)*** (Sampling)

| | | | |
|---|---|---|---|
| Initial | | 16 Minute | |
| 2 Minute | | 18 Minute | |
| 4 Minute | | 20 Minute | |
| 6 Minute | | 22 Minute | |
| 8 Minute | | 24 Minute | |
| 10 Minute | | 28 Minute | |
| 12 Minute | | 30 Minute | |
| 14 Minute | | End | |

Comments:

| SMOKE TEST | | | | | |
|---|---|---|---|---|---|
| Initial | | Intermediate | | Final | |
| Pass: ☐ | Fail: ☐ | Pass: ☐ | Fail: ☐ | Pass: ☐ | Fail: ☐ |

Comments:

| FLOW RATE (cubic feet per minute) | | |
|---|---|---|
| Initial | Intermediate | Final |
| | | |

| VACUUM (inches of water column) | | |
|---|---|---|
| Initial | Intermediate | Final |
| | | |

| EXHAUST TEMPERATURE (degree Fahrenheit) | | |
|---|---|---|
| Initial | Intermediate | Final |
| | | |

Comments:

SIGNED DATE CHECKED BY DATE

# Appendix C
# Vapor Intrusion Screening Assessment

# Vapor Intrusion Screening Assessment
# Former Navistar Facility – Waukesha, Wisconsin

This vapor pathway screening assessment was conducted to determine properties to be included in a vapor sampling investigation of buildings in the vicinity of the former Navistar facility located at 1401 Perkins Avenue in Waukesha, Wisconsin (BRRTS #02-68-098404). The pathway screening is necessary to determine whether or not there is the potential for vapor intrusion on or off the subject property.

## Conceptual Model

The subject property is located in a mixed industrial, commercial, and residential area in an urban setting. The site is underlain by 0-10 feet of fill material of mixed materials including soil, foundry sand, and other fine to coarse grained demolition debris (pieces of brick, concrete and cinders) that rests on up to 5 feet of lean clay glacial till, then approximately 10 feet of sand and gravel glacial outwash. The glacial sediments are underlain by dolomite bedrock. Groundwater is encountered within the lower several feet of the outwash and in the rock, at a depth of approximately 8 - 17 feet below ground surface (bgs) and flows east from the site towards the Fox River.

Chlorinated volatile organic compounds (CVOCs), predominately trichloroethene (TCE), have been detected in groundwater on the west side of the facility property. The extent of the CVOCs is still being assessed, but investigations by others in the 1990s detected TCE throughout the west side of the property and in monitoring wells located directly across from the property on Niagara Street to the north and Perkins Avenue to the south. Concentrations of CVOCs ranged from below detectable limits to the 100s of micrograms per liter in these offsite monitoring wells. Numerous industrial properties in the site vicinity are connected to buried utilities that drain through the subject property. The complexity of the geologic setting, in addition to commercial/industrial development, results in multiple potential sources of CVOCs detected in the groundwater, and multiple potential vapor pathways. Vapors from the impacted groundwater may volatilize and travel upwards into buildings. Vapors would likely migrate through the porous glacial outwash deposits and may be retarded, diverted, or contained by the overlying lean clay till. There are buried utilities within the subject property and City of Waukesha rights-of-way that could also serve as pathways to vapor transport. The extent and continuity of the till interval will be further evaluated as part of the Supplemental Site Investigation. For this initial assessment, it is assumed that vapors will migrate through the till and could impact properties underlain by groundwater with detections of CVOCs.

## Screening Assessment

WDNR (2010) states that "Vapor intrusion investigations should be undertaken at almost all CVOC sites…". Therefore, this vapor pathway screening assessment recommends that properties be investigated for vapor intrusion based on the current understanding of the extent of CVOCs in groundwater. The number of properties to be investigated will be modified as appropriate as the extent of impacts are further delineated and initial sampling and investigative data are available. The initial step of the investigation at each property will be a site reconnaissance to determine the most appropriate sampling strategy for each structure. Properties for investigation are illustrated in the attached figure and are as follows:

- Subject property – The RMG foundry is an operating industrial facility with numerous buildings and industrial processes. The industrial buildings have an extensive air exchange system. A comprehensive reconnaissance of the facility will be undertaken prior to conducting the vapor sampling to assess the sampling strategy that is most appropriate for the facility.
- International Pump and Tank (IPT) operates a facility at 901 Niagara Street that abuts the subject property on the north. This property was closed as the Wisconsin Coach Lines/Dairyland Buses site (BRRTS No. 03-68-004354) in 1997 with known CVOC impacts on the property.
- Commercial properties to the west. There are four commercial properties to the west of the subject property at 1324, 1344, and 1430 White Rock Avenue and 705 Elm Street that will be included in the vapor intrusion investigation. These properties are included because it is assumed that groundwater containing CVOCs extends in the direction of groundwater flow from the subject property and beneath these buildings.
- Residential properties to the north and northwest – there are three properties along White Rock Avenue and eight properties along Niagara Street that are assumed to be underlain by the extent of CVOCs in groundwater and will be included in the vapor intrusion investigation.
- Residential properties to the south – there are three properties located along Perkins Avenue that will be included in the vapor intrusion assessment based on the presumed extent of the CVOCs as measured in monitoring wells installed and sampled by others in the 1990s. This property included two former UST sites and an ERP site that was collectively known as the "McGlenn Perkins Street Property". The ERP site listed as General Castings Corporation BRRTS #02-68-168232 was closed in 1999 with known CVOC impacts on the property.