2023 Addendum 2: Vapor Intrusion Evaluation Work Plan

Wausau Water Supply NPL Site
Wausau, Wisconsin

City of Wausau

August 04, 2023
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→ **The Power of Commitment**

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The Power of Commitment

Contents

1. Introduction and Background **1**
1.1 Site Background 1
1.2 Site Contaminants of Potential Concern 2
2. VI Investigation Work Plan **2**
2.1 Overview 2
2.2 Building Assessments and Access Agreements for Sub-slab Vapor Sampling 3
3. Field Investigation Procedures **3**
3.1 Overview 3
3.2 Sub-Slab Vapor Pin Installation and Sampling 3
3.2.1 Vapor Pin Installation 3
3.2.2 Sub-slab Vapor Sampling Setup and Testing Procedures 4
3.2.3 Sub-slab Sample Collection Procedure 4
3.3 Indoor Air Sampling 5
3.4 Temporary Soil Gas Probes Installation and Sampling 6
3.4.1 Temporary Soil Gas Probe Installation 6
3.4.2 Temporary Soil Gas Probe Sampling Protocol 6
4. Reporting **7**
5. Schedule **7**

Table index

Table 1.1 Contaminants of Potential Concern Physical Properties

Figure index

Figure 1 Proposed Sub-Slab, Indoor Air, and Soil Gas Sampling Locations
Figure 2 Trichloroethene Concentrations in Groundwater (August 2022)
Figure 3 cis 1,2 Dichloroethene Concentrations in Groundwater (August 2022)
Figure 4 Tetrachloroethene Concentrations in Groundwater (August 2022)
Figure 5 Vinyl chloride Concentrations in Groundwater (August 2022)

Appendices

Appendix A	GHD Vapor Intrusion Evaluation Summary Report 2019
Appendix B	Quality Assurance Objectives
Appendix C	Field Protocols and Field Sampling SOPs
Appendix D	Sewer and Water Utility Maps
Appendix E	2023 Addendum: Vapor Intrusion Evaluation Work Plan

1. Introduction and Background

In response to the U.S. Environmental Protection Agency's (EPA) letter of January 19, 2023, this Vapor Intrusion Evaluation Work Plan Addendum provides the proposed scope of work and field procedures for vapor intrusion (VI) evaluation and investigation at the Wausau Water Supply Superfund Site in Wausau, Wisconsin (Site). This Work Plan has been prepared in accordance with the EPA guidance document *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air (June, 2015*), EPA guidance document *Region 5 Vapor Intrusion Guidebook (March, 2020),* Wisconsin Department of Natural Resources (WDNR) guidance document *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin (January, 2018),* and *WNDR Guidance for Documenting the Investigation of Human-made Preferential Pathways Including Utility Corridors (June, 2021).*

This Work Plan Addendum (Work Plan) aims to collect additional subsurface vapor data to determine the potential for vapor intrusion to indoor air on the west bank of the project. Specific tasks to be conducted include:

– Installation of sub-slab vapor and temporary soil gas sampling points

– Sampling and analysis of sub-slab soil vapor, indoor air, and soil gas

Data obtained from this proposed sampling event will be used in conjunction with existing data to fill in data gaps and update the Conceptual Site Model (CSM).

1.1 Site Background

The Wausau Superfund Site is located on the north side of the City of Wausau, in north-central Wisconsin, along the Wisconsin River in Marathon County. The Site consists of two contaminant source areas separated by the Wisconsin River. The East Bank portion of the Site is related to solvent spills on property operated by Wausau Chemical Corporation (WCC). The West Bank portion of the Site is related to the former City of Wausau landfill. The former landfill property is presently owned by Regal Beloit Corporation (formerly Marathon Electric Company). These two properties are considered source areas for contaminants in the aquifer, which is the source of drinking water for the City of Wausau.

Groundwater and soil remediation has been ongoing at the two source areas since approximately 1985. Remedial actions by the Group were initiated in the early 1990s in accordance with September 29, 1990, Record of Decision (ROD) and the Consent Decree (CD) entered with the court on January 24, 1991. Remedies implemented at the Site consisted of two soil vapor extraction (SVE) systems to address the source areas and groundwater extraction and treatment, utilizing existing municipal production wells (CW3 and CW6) and a remediation well (EW1).

Source area remediation was accomplished by installing SVE systems at Marathon Electric (West Bank) and Wausau Chemical (East Bank) in January 1994. The SVE system at Marathon Electric operated until April 1996, when the West Bank source remediation was approved as complete. The East Bank SVE system was modified in 1996 and continued to operate until January 2001. The East Bank source remediation was approved as complete in 2007.

Groundwater remediation was provided through two existing municipal production wells (CW3 and CW6) and one extraction well installed at Marathon Electric (EW1). Air strippers located at the Wausau water treatment plant treat water from the municipal supply wells. Water from EW1 was treated by air stripping (over riprap on the riverbank) before being discharged to the Wisconsin River.

EW1 stopped operating in July 2012 due to pump failure. Since EW1 has essentially completed its performance goal, the Group proposed a pilot study to confirm that City wells CW6 and CW3 effectively contain the contaminant plume without pumping at EW1. The EW1 Shutdown, Pilot Study Report, was submitted to EPA in March 2015.

Additional groundwater remediation was provided by a groundwater extraction system operated by WCC between 1985 and 1996 as an interim remediation measure. The extraction system at WCC consisted of a series of shallow wells at the south end of the WCC property. Groundwater from this system was treated by air stripping. This system was in addition to the requirements of the ROD or the CD and operation ceased in 1996.

From March 2017 to April 2019 GHD performed additional field work to supplement existing Site data to better understand the potential for vapor intrusion (VI) risk in areas adjacent to the known groundwater plume footprints at the Site. The VI Evaluation Summary Report is provided in Appendix A. In January 2023 an addendum to the approved work plan was submitted and approved. In March 2023 an additional round of VI sampling was conducted and included sub-slab and indoor air samples on the east and west bank in the commercial/industrial buildings.

1.2 Site Contaminants of Potential Concern

Site contaminants of potential concern (COPC) are limited to the following chlorinated VOCs:

East Bank

– Tetrachloroethylene (PCE)
– Trichloroethylene (TCE)
– cis-1,2-Dichloroethylene (c12DCE)
– Vinyl chloride

West Bank

– Trichloroethylene
– cis-1,2-Dichloroethylene
– Carbon tetrachloride (CT)
– Chloroform

The physical properties of these VOCs are summarized in Table 1.1. Significant concentrations of CT and chloroform were detected in only one well, C3S, which is a shallow well in the former City landfill. These compounds were not detected from Marathon Electric property and are limited to the landfill.

The East Bank COPCs are related to a release of PCE, which has degraded over time to TCE, c12DCE, and low concentrations of vinyl chloride.

Please refer to Figures 2 through 5 for the August 2022 ground water analytical results on the West Bank.

2. VI Investigation Work Plan

2.1 Overview

This work plan presents the procedures for additional investigations and evaluations to help complete the conceptual site model relative to VI. Existing groundwater data do not suggest an immediate VI risk to residential or commercial/industrial properties. Proposed fieldwork includes:

1. Install additional vapor pins at the select locations as shown on Figure 1.
2. Collect sub-slab, indoor air, and soil gas samples from the (Marathon Electric now Rexnord north and south buildings) on the West Bank.

The additional requested VI investigation activities will provide additional lines of evidence to better determine potential VI risks.

The elements of the field investigations are presented below. Field procedures are detailed in Section 3 and quality assurance (QA) objectives are presented in Appendix B.

2.2 Building Assessments and Access Agreements for Sub-slab Vapor Sampling

Additional sub-slab vapor sampling is proposed for commercial buildings, as noted above. Upon implementing this work plan addendum, notification will be provided the Rexnord (whom is one of the clients) regarding the proposed sampling event. The client is aware of the proposed sampling work plan and has no issues which what is being proposed. However, once this addendum is approved an email will be sent out providing and explanation of the proposed fieldwork and describe where the locations where sub-slab sampling is proposed as part of the investigation.

Sub-slab sampling will be assessed to obtain information that can be used to help interpret results and better assess potential VI risk. Information to be obtained by these assessments includes the following:

1. Basement depth or crawlspace; the presence of a sump
2. Basement floor type; concrete, soil, other
3. Locations of normally occupied areas
4. Type of ventilation; air exchange rates
5. Radon mitigation, vapor barrier
6. Chemical usage/inventory

3. Field Investigation Procedures

3.1 Overview

The following sections describe the installation of sampling devices and sampling procedures for each media to be evaluated during VI investigation activities. Proposed investigation locations are presented on Figures 1.

3.2 Sub-Slab Vapor Pin Installation and Sampling

3.2.1 Vapor Pin Installation

With the property owner's permission, one or more sub-slab vapor pins will be installed in the basement or floor slab of the subject property. The number of potential pins will depend on the size of the floor area and layout of the building. One to three sub-slab vapor pins will be installed per building at locations agreed upon by GHD and the building owner/manager. The following describes the procedures for the installation of sub-slab pins.

1. Prior to drilling holes in a foundation or slab, utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines) will be located. The sample location will be cleared using knowledgeable site personal or a private utility locate company.
2. Prior to installation of the sub-slab Vapor Pin™, a rotary hammer drill will be used to drill a 1.5-inch diameter outer hole to a depth of approximately 1 inch below the surface that partially penetrates the slab. This outer hole will allow the protective cap to be flush with the concrete surface.
3. A small portable vacuum cleaner will be used to remove cuttings from the hole.
4. A rotary hammer drill with a 5/8-inch bit will be used to drill an inner hole through the remainder of the slab to a depth of 4 inches below the slab. Drilling into the sub-slab material will create an open cavity, which will prevent the obstruction of any pins during sampling.
5. A 3/4–inch diameter bottle brush and a small portable vacuum cleaner will be used to remove cuttings from the hole.

6. The thickness of the slab will be measured and recorded.
7. A Vapor Pin™ assembly will be driven into the 5/8-inch hole. The Vapor Pin™ creates an airtight seal without the need for cement.
8. The Vapor Pin™ will be capped to prevent air exchange between the subsurface and indoor air and a flush-mount cap will be placed at the concrete surface so as to not interfere with day-to-day use of the building.

Sub-slab pins constructed in the aforementioned manner can be abandoned by removing any tubing and all surface protective covers. The Vapor Pin™ can be removed using a tool provided with the installation kit. The hole can then be backfilled with cement grout.

3.2.2 Sub-slab Vapor Sampling Setup and Testing Procedures

The sub-slab sampling assembly will be connected to the Vapor Pin™. Once connected, the sampling assembly will consist of the soil gas pin, Teflon tubing, vacuum gauge supplied by the laboratory, personal sampling pump, and vacuum canister, all connected in series (i.e., in the order of soil gas pin, vacuum gauge, pump, and canister), using T-connectors or T-valves.

A personal sampling pump, or similar, will be used to conduct a vacuum test. The SOP for vacuum testing is presented in Appendix D.

If the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.

3.2.3 Sub-slab Sample Collection Procedure

1. Sub-slab vapor samples will be collected using the water dam method to prevent potential air leaks during sampling. The SOP for the water dam method is presented in Appendix D.
2. Sub-slab vapor samples will be collected using batch certified clean vacuum canisters. Only canisters certified clean at the 100 percent level will be used for soil gas sampling activities Vacuum canisters will have a capacity of 1-liter or 6-liters depending on laboratory requirements and availability.
3. The canisters will be fitted with a laboratory-calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min). The 100 mL/min maximum flow rate is equivalent to a sample collection time of 60 minutes for a 6-liter canister.
4. A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection.
5. The canister will be connected to the soil vapor pin using a sampling assembly comprised of short lengths of ¼-inch Teflon or Teflon lined tubing and polypropylene valves and fittings. The canister will be connected to the soil vapor pin along with the vacuum gauge and a purge pump (for soil vapor pin purging), in series. A T-valve will be used to connect the purge pump, which allows the pump to be isolated from the sampling assembly during sample collection. New tubing will be used for each sample.
6. Prior to collecting a soil gas sample, the stagnant air in the sampling assembly tubes and soil gas pin will be removed. The soil gas pins will be purged prior to sampling using a sampling pump at a flow rate of not more than 200 mL/min. Prior to sample collection, three purge volumes will be drawn from the pin/sample assembly.
7. At the start and the end of the purging period, the total concentration of volatile organic vapors of the pump exhaust gas should be monitored using a (PID). The PID will be connected in series after the personal sampling pump. PID readings will be recorded and entered in the field logbook. If VOCs are detected by the PID, the laboratory will be advised whether a sample could require dilution before analysis.
8. Following purging, the valve to the purge pump will be closed, and the valves to the soil gas pin and vacuum canister opened to draw the soil gas sample into the canister. This should be completed concurrent with continued application of the leak-testing water dam.

9. To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded after approximately 8 minutes of the expected 10-minute sample collection duration. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until the vacuum reading is below this threshold. A minimum 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap must be securely tightened on the inlet of the vacuum canister prior to shipment to the laboratory under chain-of-custody procedures.
10. The critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves will not be re-used during sampling.
11. The vacuum canister samples will be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all soil gas sampling data.

East Bank vapor samples will be analyzed for PCE, TCE, c12DCE, and vinyl chloride. West Bank samples will be analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

The indoor air samples will only be analyzed if the corresponding sub-slab samples show any exceedances.

Sub-slab vapor sampling QA objectives for the TO-15 analytical method are provided in Appendix B. Field procedures are presented in Appendix D.

3.3 Indoor Air Sampling

Sub-slab and indoor air sampling are being proposed for commercial/industrial buildings. Indoor air samples will be collected concurrently with sub-slab samples in accordance with WDNR guidance. All indoor air samples will be held by the laboratory and will only be analysed if there are exceedance in sub-slab for the following analytes TCE, c12DCE, CT, chloroform, and vinyl chloride.

A summary of the steps involved in the indoor air sampling is presented below:

1. Similar to the soil gas samples, the indoor air samples will be collected using laboratory-certified pre-cleaned 6-liter stainless steel vacuum canisters. Canisters will be certified as pre-cleaned at the 100 percent level in accordance with EPA Method TO-15.
2. Sample canisters will be fitted with laboratory-calibrated critical orifice flow regulators sized to restrict the maximum air sample collection flow rate into the canister and provide a sample collection duration of approximately 24 hours.
3. The laboratory will supply a vacuum gauge for each canister and will be used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection.
4. The canisters will be deployed at a typical breathing zone height of approximately 4 to 5 ft. above the floor/ground surface.
5. Collection of field duplicate indoor air samples will be achieved by deploying two canisters side by side simultaneously with a single inlet and a T-connection. Field duplicate samples will be collected at a frequency of 1 in 20 indoor air and outdoor ambient air samples per sampling event.
6. Indoor air sampling will be continued until the vacuum reading is between -10 and -5 in Hg. The vacuum gauge reading must not be greater than -1 in Hg for the sample to be considered valid. After recording the final canister vacuum reading, the canister valve will be closed and the safety cap securely tightened on the inlet of the canister. Sample canisters will be shipped to the laboratory under chain-of-custody procedures.
7. The canister serial numbers will be recorded and a unique sample identification number will be assigned to each canister/sample identifying the sample number, date, time, and sampler's initials. A bound field logbook will be maintained to record all indoor air/outdoor ambient air sampling field measurements.

East Bank indoor air and ambient air samples will be analyzed for PCE, TCE, c12DCE, and vinyl chloride. West Bank indoor and ambient air samples will be analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

Indoor air sampling QA objectives TO-15 analytical method are provided in Appendix B. Field procedures are presented in Appendix D.

3.4 Temporary Soil Gas Probes Installation and Sampling

3.4.1 Temporary Soil Gas Probe Installation

Two soil gas samples will be collected on-Site from west of the Marathon Electric Building B to evaluate soil vapor conditions at the property boundary. The soil gas samples will be collected from temporary soil gas locations (SG-1 and SG-2) advanced during this phase of work. The temporary probes samples will be collected from approximately 10-feet below ground surface to obtain data from a depth corresponding to the base of a typical residential basement.

To minimize soil disturbance, temporary soil gas samples will be collected using the Geoprobe Post Run Tubing (PRT) soil vapor extraction system. This system entails driving drill rods, using a direct push rig, to the target depth and then inserting the PRT adapter connected to tubing extending to the surface. The PRT system utilizes O-rings to deliver a vacuum tight seal the prevents sample contamination from above the sample collection point. Soil gas is drawn through the point holder, through the adapter, and into the sample tubing. Upon completion of sample collection, PRT sampling assembly will be removed and the soil boring backfilled with hydrated bentonite chips.

3.4.2 Temporary Soil Gas Probe Sampling Protocol

Once the PRT tooling has been placed at the target depth, a sampling canister will be affixed to the tubing using Swagelok fittings in preparation for sample collection. Soil gas samples from the temporary proves will be collected using the following procedures:

1. Temporary soil gas samples will be collected using batch certified clean vacuum canisters. Only canisters certified clean at the 100 percent level will be used for soil gas sampling activities. Vacuum canisters will have a capacity of 1-liter or 6-liters depending on laboratory requirements and availability.
2. The canisters will be fitted with a laboratory-calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min). The 100 mL/min maximum flow rate is equivalent to a sample collection time of 60 minutes for a 6-liter canister.
3. A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection.
4. The canister will be connected to the temporary soil gas probe using a short length of ¼-inch Teflon or Teflon lined tubing. The canister will be connected to the soil probe along with the vacuum gauge. New tubing will be used for each sample.
5. To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded after approximately 8 minutes of the expected 10-minute sample collection duration. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until the vacuum reading is below this threshold. A minimum 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap must be securely tightened on the inlet of the vacuum canister prior to shipment to the laboratory under chain-of-custody procedures.
6. The critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves will not be re-used during sampling.
7. The vacuum canister samples will be labelled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all soil gas sampling data.

West Bank samples will be analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

Sub-slab vapor sampling QA objectives for the TO-15 analytical method are provided in Appendix B. Field procedures are presented in Appendix D.

4. Reporting

Laboratory results will be provided as GHD receives them from the lab. After completing the scope of work described herein, a field investigation report will be prepared for submittal to WDNR and EPA. The report will include a narrative of the field investigation activities, tabulated data, figures, data interpretation, laboratory reports, and recommendations. A final report will be prepared for review by WDNR and EPA.

5. Schedule

It is anticipated that the field investigation described herein will take approximately two to four days to complete, although property access issues could potentially delay portions of the investigation.

Upon completion of the supplemental VI evaluation, a final report will be submitted to WDNR and EPA within 90 days after receipt of the final laboratory report.

Table

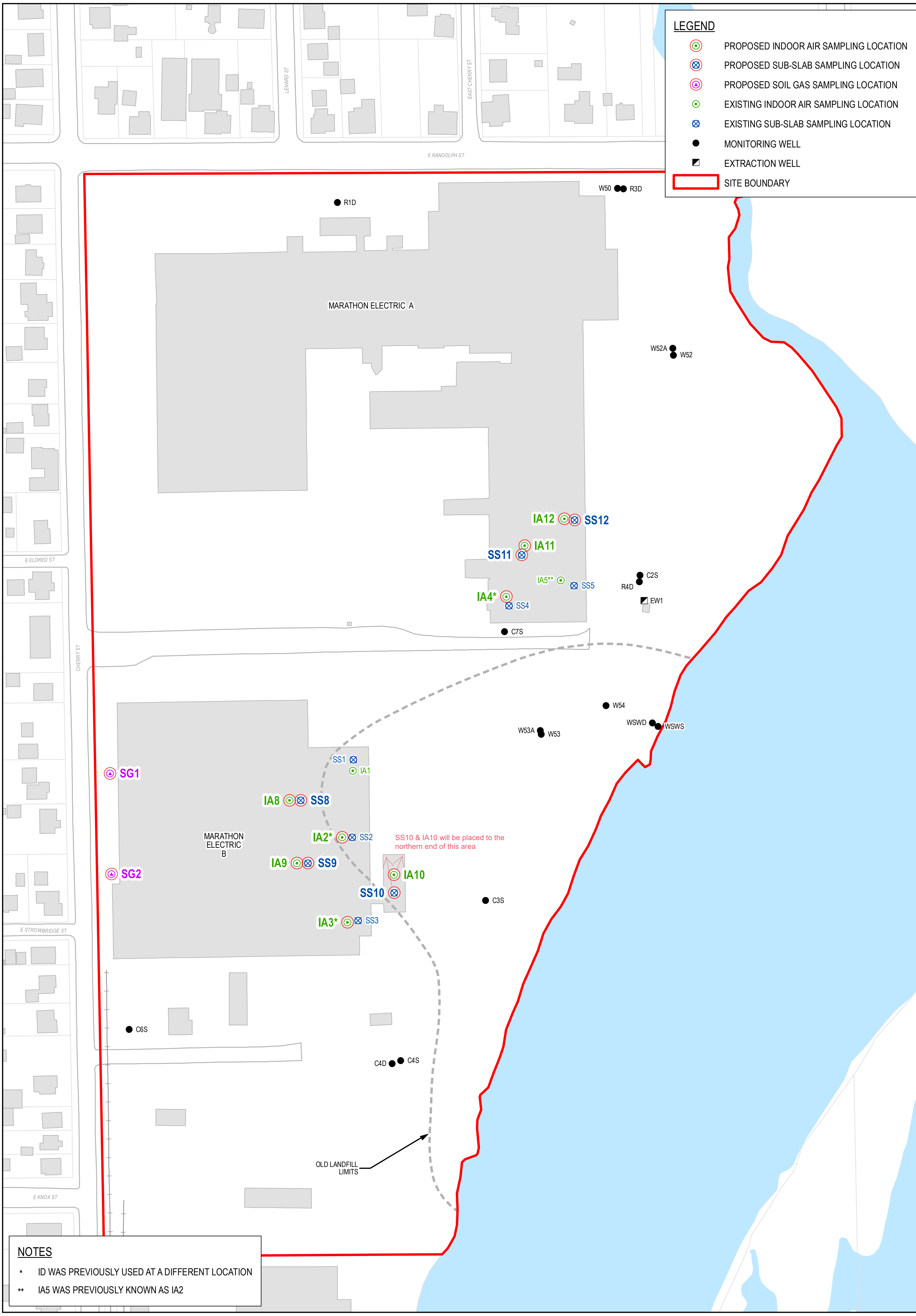
Table 1.1

Contaminants of Potential Concern Physical Properties
Vapor Intrusion Work Plan Addendum
Wausau Water Supply Superfund Site
Wausau, Wisconsin

Chemical	CAS No.	Molecular Weight (g/mole)	Henry's Law Constant (unitless)	Vapor Pressure (mm Hg)	Density (g/cm^3)	Diffusivity in Air (cm^2/sec)	Diffusivity in Water (cm^2/sec)	Soil Partition Coefficient Koc (L/kg)	Water Partition Coefficient log Kow (L/kg)	Water Solubility (mg/L)	Permeability Coefficient K_p (cm/hr)
Tetrachloroethene	127-18-4	165.83	7.20E-01	1.90E+01	1.60E+00	5.00E-02	9.50E-06	9.50E+01	3.40E+00	2.10E+02	3.30E-02
Trichloroethene	79-01-6	131.39	4.00E-01	6.90E+01	1.50E+00	6.90E-02	1.00E-05	6.10E+01	2.40E+00	1.30E+03	1.20E-02
cis-1,2- Dichloroethene	156-59-2	96.94	1.70E-01	2.00E+02	1.30E+00	8.80E-02	1.10E-05	4.00E+01	1.90E+00	6.40E+03	1.10E-02
Vinyl chloride	75-01-4	62.5	1.10E+00	3.00E+03	9.10E-01	1.10E-01	1.20E-05	2.20E+01	1.60E+00	8.80E+03	8.40E-03
Carbon Tetrachloride	56-23-5	153.82	1.10E+00	1.20E+02	1.60E+00	5.70E-02	9.80E-06	4.40E+01	2.80E+00	7.90E+02	1.60E-02
Chloroform	67-66-3	119.38	1.50E-01	2.00E+02	1.50E+00	7.70E-02	1.10E-05	3.20E+01	2.00E+00	8.00E+03	6.80E-03

Source: Vapor Intrusion Screening Level (VISL) Calculator Version 3.4, June 2015 RSLs

Figures



Paper Size ANSI B

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Feet

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SUB-SLAB, INDOOR AIR, AND SOIL GAS SAMPLING LOCATIONS

Project No. 003978-00
Revision No. -
Date 08/03/2023

FIGURE 1

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

TRICHLOROETHENE CONCENTRATIONS AUGUST 2022

Project No. 003978-00
Revision No. -
Date 08/03/2023

FIGURE 2

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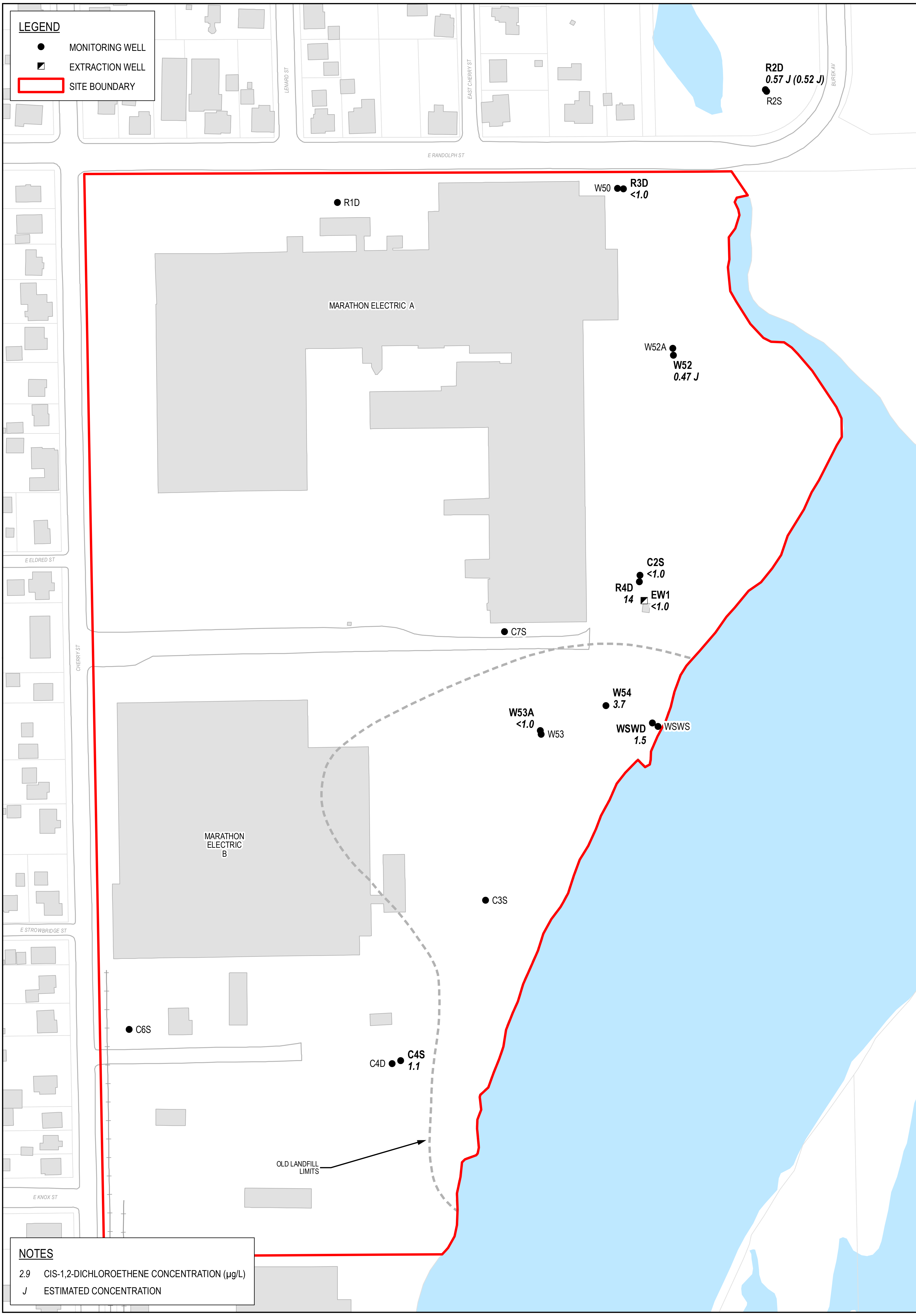

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

CIS-1,2-DICHLOROETHENE CONCENTRATIONS AUGUST 2022

Project No. **003978-00**
Revision No. **-**
Date **08/03/2023**

FIGURE 3

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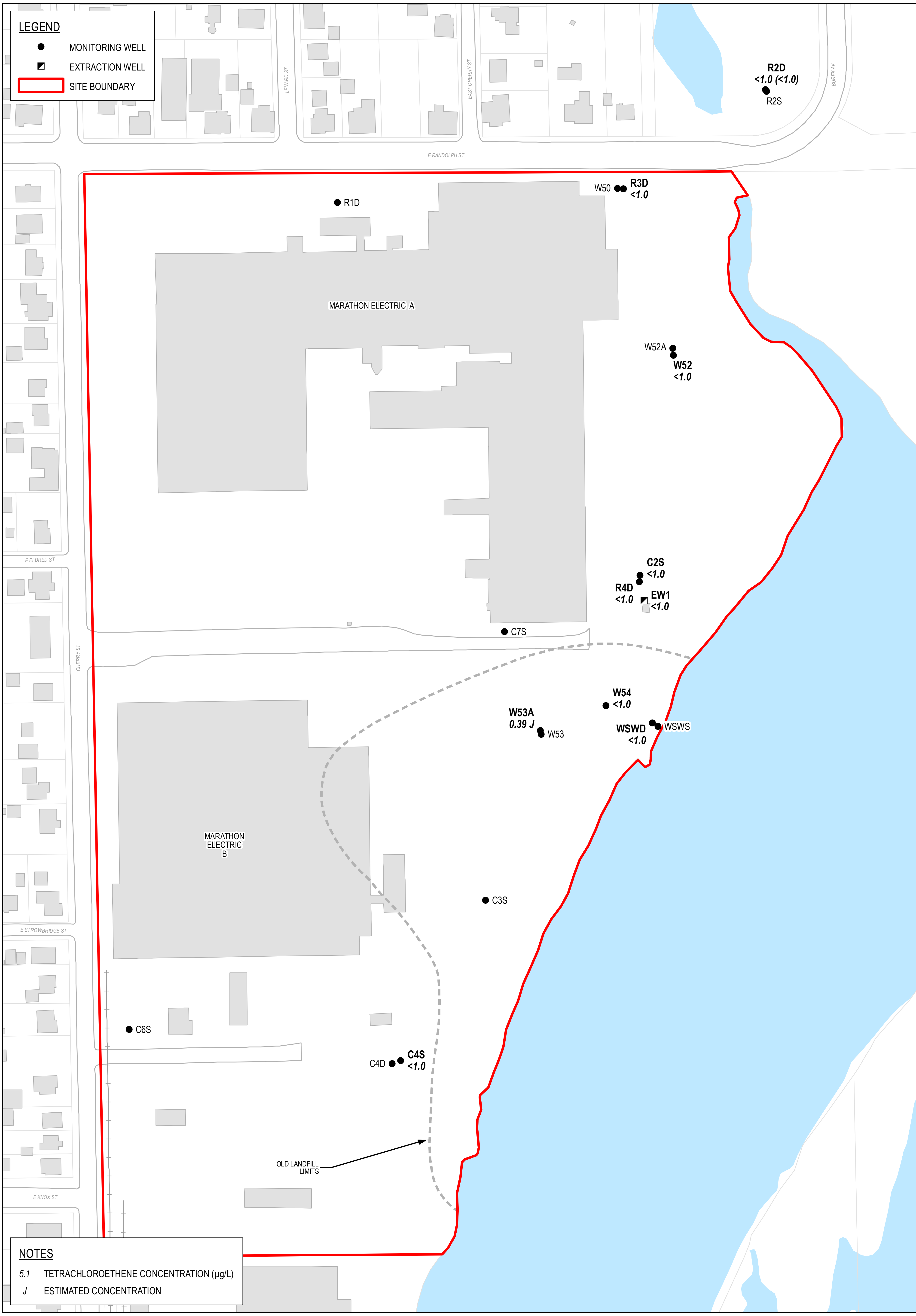

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Map Projection: Lambert Conformal Conic
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Grid: NAD 1983 HARN WISCRS Marathon County Feet

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

TETRACHLOROETHENE CONCENTRATIONS AUGUST 2022

Project No. 003978-00
Revision No. -
Date 08/03/2023

FIGURE 4

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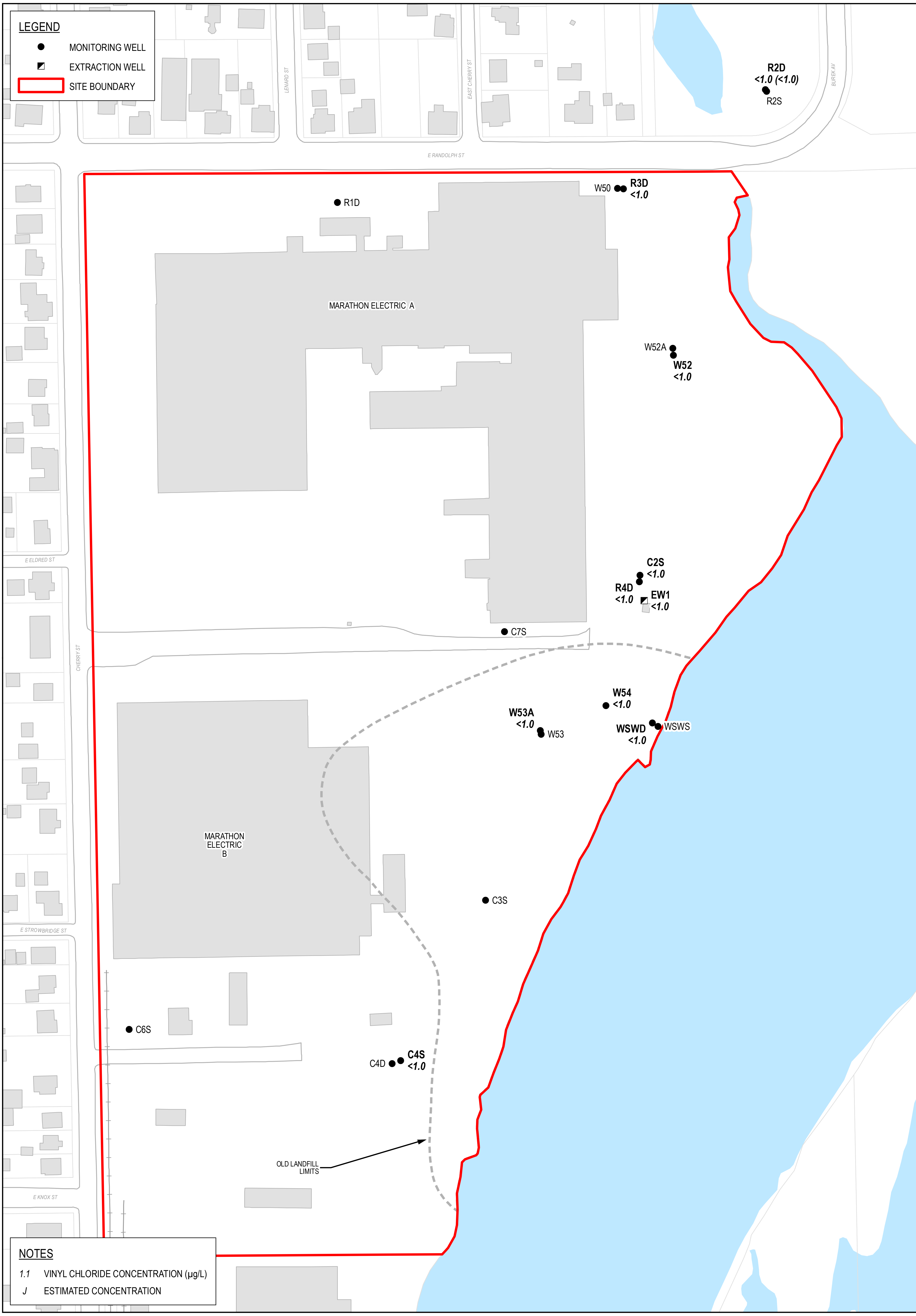

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

VINYL CHLORIDE CONCENTRATIONS
AUGUST 2022

Project No. 003978-00
Revision No. -
Date 08/03/2023

FIGURE 5

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Appendices

Appendix A

GHD Vapor Intrusion Evaluation Summary Report 2019

January 29, 2020

Reference No. 003978

Sheri Bianchin
Remedial Project Manager
EPA Region 5
77 West Jackson Blvd.
Chicago, IL 60604-3590

Matt Thompson
Hydrogeologist
Wisconsin Department of Natural Resources
1300 W. Clairemont Avenue
Eau Claire, Wisconsin 54701

Dear Ms. Bianchin and Mr. Thompson:

Re: Vapor Intrusion Evaluation Summary Report
Wausau Water Supply NPL Site
Wausau, Wisconsin

1. Overview

From March 2017 to April 2019 GHD performed additional field work to supplement existing Site data in an effort to better understand the potential for vapor intrusion (VI) risk in areas adjacent to the known groundwater plume footprints at the Site. These activities are listed below and summarized in greater detail in the sections to follow. Figure 1 presents a Site Plan.

1. Installed temporary monitoring wells and collected groundwater samples for volatile organic compound (VOC) analysis to further delineate groundwater impacts in residential and commercial/industrial areas on the West Bank and East Bank. This was conducted in March 2017 and is summarized in Section 1.2.
2. Installed vapor probes and collected vapor samples to delineate the horizontal and vertical extent of potential VOCs in the vadose zone on the West Bank and East Bank. Two sampling rounds were conducted in March 2017 and August 2017 as summarized in Section 1.3.
3. Collected sub-slab and indoor air samples at select residential and commercial/industrial buildings on the West Bank and East Bank. West Bank samples were collected on two occasions in March 2017 and August 2017. The West Bank results are summarized in Section 1.4. East Bank sub-slab and indoor air sampling has occurred on six occasions from April 2017 through September 2019. These results are summarized in Section 1.4.

1.1 Additional Groundwater Sampling Results

Additional groundwater delineation was conducted to the east of monitoring well E24AR on the East Bank and north of Marathon Electric property on the West Bank in March 2017. These groundwater samples were collected from temporary wells that were removed after sample collection. VOC data from these locations were used to confirm and establish the extent of potential groundwater vapor sources.

1.1.1 East Bank Groundwater Sampling

On March 6 and 7, 2017, groundwater samples were collected on the East Bank to further delineate the eastern extent of the groundwater plume. Temporary wells were installed at nine locations (E1 through E9) as shown on Figure 2. Samples from these wells were analyzed for tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (c12DCE), and vinyl chloride.

While groundwater samples from temporary wells E1 through E7 all had VOC detections, only temporary wells E2 (15 µg/L TCE) and E4 (5.4 µg/L vinyl chloride) had VOC concentrations that slightly exceeded the VI screening level for groundwater[1]. Temporary wells E8 and E9 had no detections. All East Bank groundwater sampling results are shown in Table 1.

The East Bank groundwater delineation sampling results indicated that the eastern limit of the VOC plume was between N 2nd Street and N. 3rd Street, and the southern limit was north of Lincoln Avenue (see Figure 2).

1.1.2 West Bank Groundwater Sampling

Potential VI sources on the West Bank are related to shallow groundwater and soils in the former City landfill. On March 8 and 9, 2017, groundwater samples were collected adjacent to Marathon Electric building "A" to further delineate the groundwater plume adjacent to and immediately downgradient from the fill area. Additionally, shallow groundwater samples were collected at select locations north of Marathon Electric property to confirm that the shallow aquifer is not impacted in that area. A total of seven temporary wells (W1 through W7), as shown on Figure 2, were installed on the West Bank. Samples from these wells were analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

Of the groundwater samples collected from the seven temporary wells on the West Bank, only two samples contained VOCs at detectable concentrations. Temporary well W2 had a TCE detection of 1.0 µg/L. Temporary well W4, directly downgradient from W2 had a chloroform concentration on 2.1 µg/L. None of the groundwater samples collected from the West Bank temporary wells had VI screening level exceedances. All West Bank groundwater sampling results are shown in Table 1.

The West Bank groundwater delineation sampling results indicated that the VOC plume is primarily within the deeper portion of the aquifer and VOCs in the shallow portion of the aquifer do not extend far from the landfill.

1.2 Soil Vapor Sampling Results

Vapor samples were collected at each of the East Bank and West Bank groundwater delineation temporary well locations. Vapor probes were constructed with 6-inch stainless steel screen implants attached to ¼" polyethylene tubing. Two vapor probe sampling events were conducted in the spring and

[1] USEPA VISL Calculator with 10-5 additional cancer risk.

late summer of 2017. All vapor probes were sampled using stainless steel vacuum canisters and samples were analyzed by the TO-15 method. Vapor probe locations are depicted on Figure 2.

1.2.1 East Bank Vapor Probes

In March 2017, vapor probes were installed at each of the nine East Bank groundwater sampling locations described in Section 1.1.1. For locations where the depth to groundwater was greater than 20 feet (E2 and E4 through E9), vapor sample collection was attempted at two depths, one just above the water table and the other at 8.5 to 9 ft bgs (assumed basement depth). At the two locations where the water table was 20 ft bgs or shallower (E1 and E3), only one sample was collected. These probes were screened from 8.5 to 9 ft bgs as well. There were nine total shallow probes and seven total deep probes (16 probes total) on the East Bank. Samples were collected using vacuum canisters and were analyzed by the TO-15 method. East Bank vapor analytes include PCE, TCE, c12DCE, and vinyl chloride.

March 2017 East Bank vapor probe sampling results are presented in Table 2. The shallow probe at location E7 had water in the screened interval and was not sampled. All 15 of the remaining probes were successfully sampled. All 15 probes had detectable VOC concentrations, although none exceeded their respective residential or small industrial screening levels.

On August 1, 2017, GHD collected a second round of soil vapor samples from the East Bank probes. August 2017 East Bank vapor probe sampling results are also provided in Table 2. The single probe installed at E3 and both shallow and deep probes installed at E6 were not sampled because they were removed due to road construction. The shallow probe installed at E7 was not sampled due to the presence of water in the probe. Of the remaining 12 probes, all had detectable VOC concentrations, although none exceeded their respective residential or small industrial screening levels.

1.2.2 West Bank Vapor Probes

In March 2017, vapor probes were installed at each of the seven West Bank groundwater sampling locations described in Section 1.1.2. For locations where the depth to groundwater was greater than 20 feet (W1 through W4 and W7), vapor samples were attempted to be collected at two levels, one just above the water table and the other at 8.5 to 9 ft. bgs (assumed basement depth). At the two locations where the water table was 20 ft. bgs or shallower (W5 and W6), only one sample was collected. These probes were screened from 5.5 to 6 ft. bgs. There were seven total shallow probes and five total deep probes (12 probes total). Samples were collected using vacuum canisters and were analyzed by the TO-15 method. West Bank vapor analytes include TCE, c12DCE, vinyl chloride, CT, and chloroform.

On March 13 and 14, 2017, GHD collected soil vapor samples from the 12 West Bank probes and these sampling results are presented in Table 2. All probes had detectable VOC concentrations, although none exceeded their respective residential or non-residential screening levels.

On August 1, 2017, GHD collected a second round of soil vapor samples from the 12 West Bank probes. August 2017 West Bank vapor probe sampling results are included in Table 2. W6 was not sampled due to water in the probe. All of the 11 probes sampled had detectable VOC concentrations, although none exceeded their respective USEPA residential or large industrial screening levels.

1.3 Sub-slab and Indoor Air Sampling Results

Sub-slab vapor and indoor air sampling was conducted at residential and commercial buildings that were identified as potential vapor intrusion risks based on their proximity to source areas or elevated groundwater concentrations. The scope of this evaluation included assessments of residential and commercial/industrial buildings for occupancy, construction, basements, ventilation, and presence of radon mitigation system. Where access was granted, sub-slab/indoor air locations were sampled at least twice to confirm the initial results.

1.3.1 East Bank Sub-slab and Indoor Air Sampling

The initial vapor sampling on the East Bank occurred at five residential properties along North 2nd Street and one commercial property (Bridge Community Clinic). Sample locations are shown on Figure 3. Sampling rounds were conducted in April, May, and July 2017, and in March 2018. Two to four samples were collected from the six locations and each sample was analyzed using the TO-15 method for PCE, TCE, c12DCE, and vinyl chloride. Sub-slab and indoor air laboratory results are presented in Table 3.

Based on an additional groundwater result obtained from monitoring well WW-6 in the fall of 2017, an additional residential property (2108 N. 3rd St.) was added to the March 2018 sampling round. Subsequent monitoring events included the commercial property at 200 E. Wausau Avenue (D&J Rentals) and a residential property at 2103 N. 3rd Street. Two adjacent residential properties and one commercial property (Thrive Foodery) were contacted to request access for sampling, but access was not obtained. Sub-slab and indoor air results for all sampling events are included in Table 3. A summary of the sequence of sampling events and the locations sampled, as well as a list of the properties that were contacted but either did not respond or denied access is provided in Table 4..

1.3.1.1 East Bank Residential Sub-slab and Indoor Air Results

USEPA/WDNR sub-slab screening levels are included on Table 3. The residential sub-slab screening level for TCE (70 µg/m3) was exceeded in three of the 18 samples collected and each of the three exceedances were from a different location. The highest sub-slab TCE concentration was 160 µg/m3. However, three other samples from the same location did not exceed 12 µg/m3. The screening levels for PCE and vinyl chloride were not exceeded in any of the sub-slab samples.

A total of 23 residential indoor air samples were collected from eight homes. The indoor air action levels were not exceeded in any of the samples except for one basement sample that slightly exceeded the TCE action level of 2.1 µg/m3. Two subsequent TCE results for that location (1917 N. 2nd St.) were 0.28 µg/m3 and 1.6 µg/m3. The basement at 1917 N. 2nd St. is unfinished and is used solely for laundry and storage.

1.3.1.2 East Bank Small Commercial Sub-slab and Indoor Air Results

Two small commercial properties were evaluated as part of the sub-slab/indoor air investigation. Samples were collected in April and July, 2017, at the Bridge Community Clinic and samples were collected in April and September, 2019, at J & D Rentals. The lab results are included in Table 3. The basements of both of these locations are near the water table and PCE and TCE were detected in all sub-slab samples. Concentrations were assessed relative to the USEPA/WDNR small commercial screening levels and none of the results exceeded an action level.

PCE and TCE were also detected in all of the indoor air samples collected in the basement level of the two buildings, but all concentrations were far below their respective action levels, as shown on Table 3.

Based on the East Bank residential and commercial indoor air results, there does not appear to be a health risk at the tested properties related to potential vapor intrusion of Site chemicals. No additional vapor intrusion evaluation is recommended.

1.3.2 West Bank Sub-slab and Indoor Air Sampling

Sub-slab and indoor air sampling on the West Bank was limited to Marathon Electric (Regal) property. Groundwater results from residential areas hydraulically downgradient from Marathon Electric revealed that the shallow groundwater is not impacted. Thus, additional vapor intrusion evaluation of the West Bank residential area is not needed.

Based on the close proximity of Marathon Electric buildings to the former City landfill, sub-slab sampling was performed at six total locations in the two buildings closest to the former landfill. Sub-slab and indoor air sample locations are shown on Figure 4. Two sampling events were performed in March and August 2017. All samples were collected using vacuum canisters and laboratory analysis was performed using the TO-15 method. West Bank vapor analytes included TCE, c12DCE, CT, chloroform, and vinyl chloride.

1.3.2.1 West Bank Sub-slab and Indoor Air Results

West Bank sub-slab results are presented Table 5. The vapor data were compared to sub-slab screening levels and indoor air action levels for large industrial buildings. The sub-slab TCE concentrations from both sampling events at SS-2 beneath Building B and at SS-5 beneath Building A exceeded the screening level of 880 µg/m3. Chloroform and CT were also detected in some of the sub-slab samples, but all concentrations were below their respective screening levels.

Indoor air samples were collected from one location inside each building, as shown on Figure 4. TCE, CT, and chloroform were detected in both sampling events, but all concentrations were far below the indoor air action levels for large industrial buildings.

Since the indoor air concentrations did not suggest a health risk to Marathon Electric employees, no additional vapor intrusion evaluation is recommended on the West Bank.

Groundwater VOC concentrations are expected to continue their long term decline. However, GHD will continue evaluating groundwater data and if concentrations increase in the shallow aquifer, potential additional vapor intrusion evaluation will be conducted.

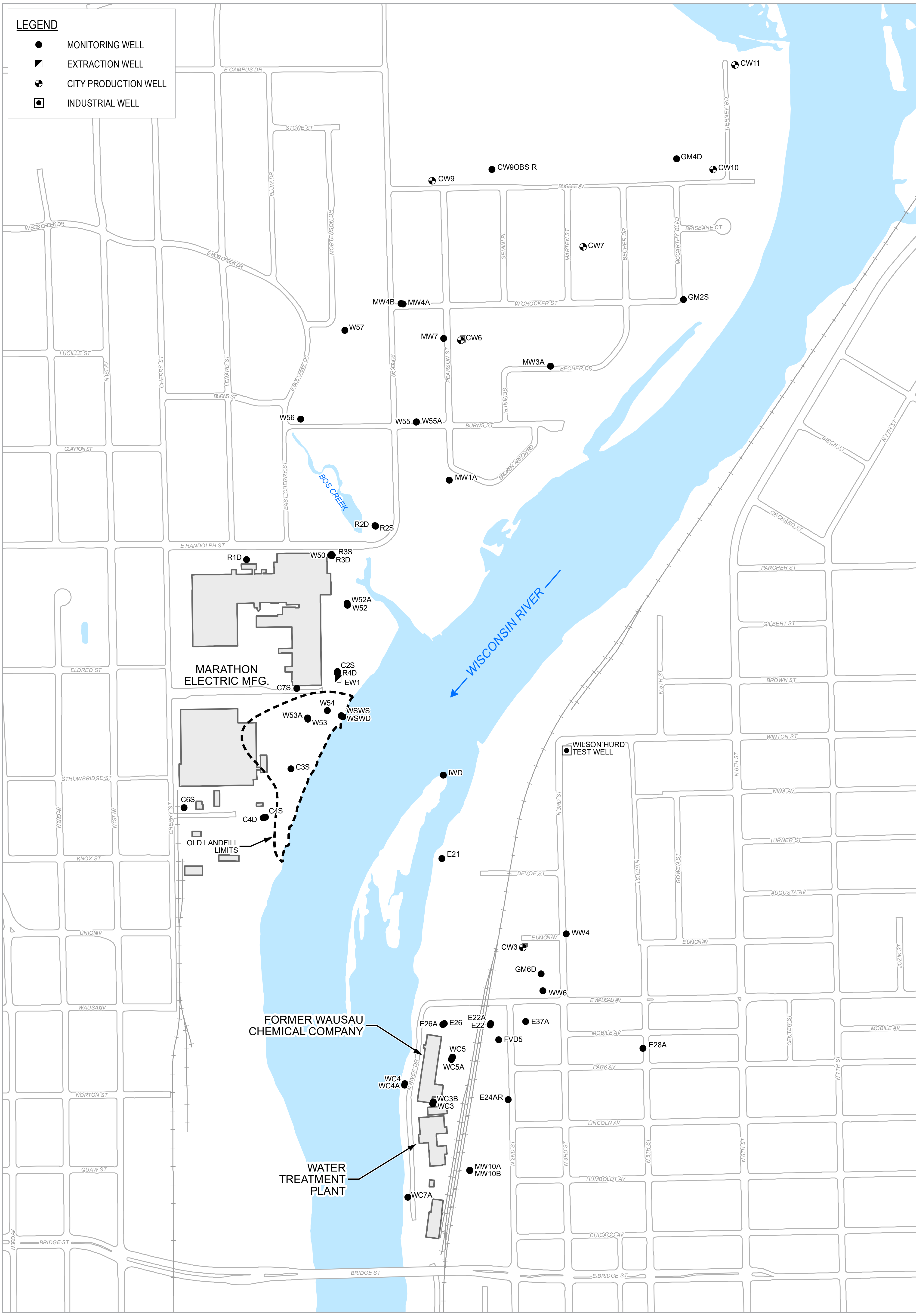
Sincerely,

GHD

Charles Ahrens Kiel Jenkin

CA/sb/1

Encl.



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Feet

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SITE PLAN

Project No. **003978-00**
Revision No. **-**
Date **01/28/2020**

FIGURE 1

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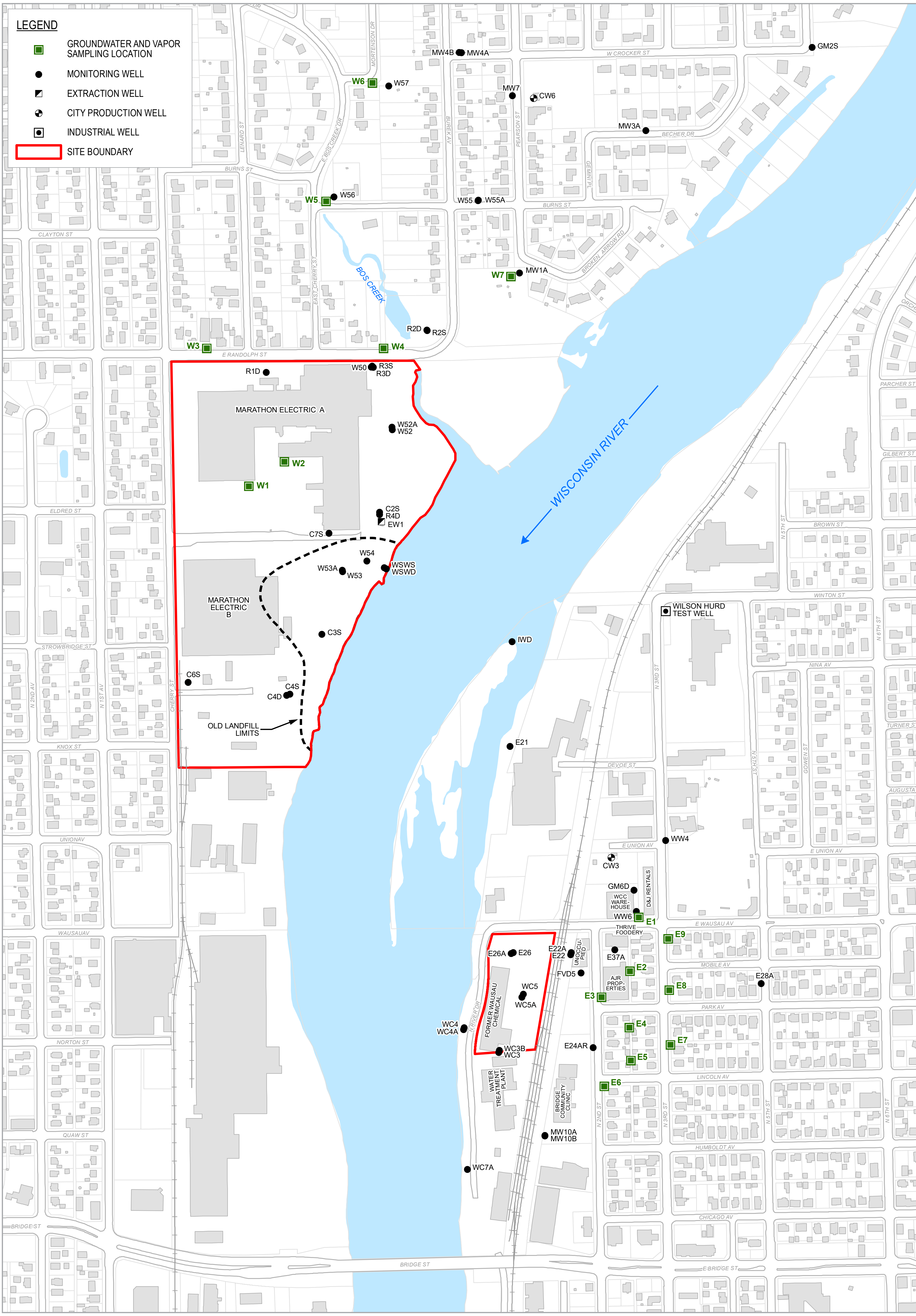

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SHALLOW AQUIFER DELINEATION LOCATIONS AND SOIL VAPOR PROBE LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/28/2020

FIGURE 2

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Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

EAST BANK SUB-SLAB VAPOR AND INDOOR AIR SAMPLE LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/28/2020

FIGURE 3

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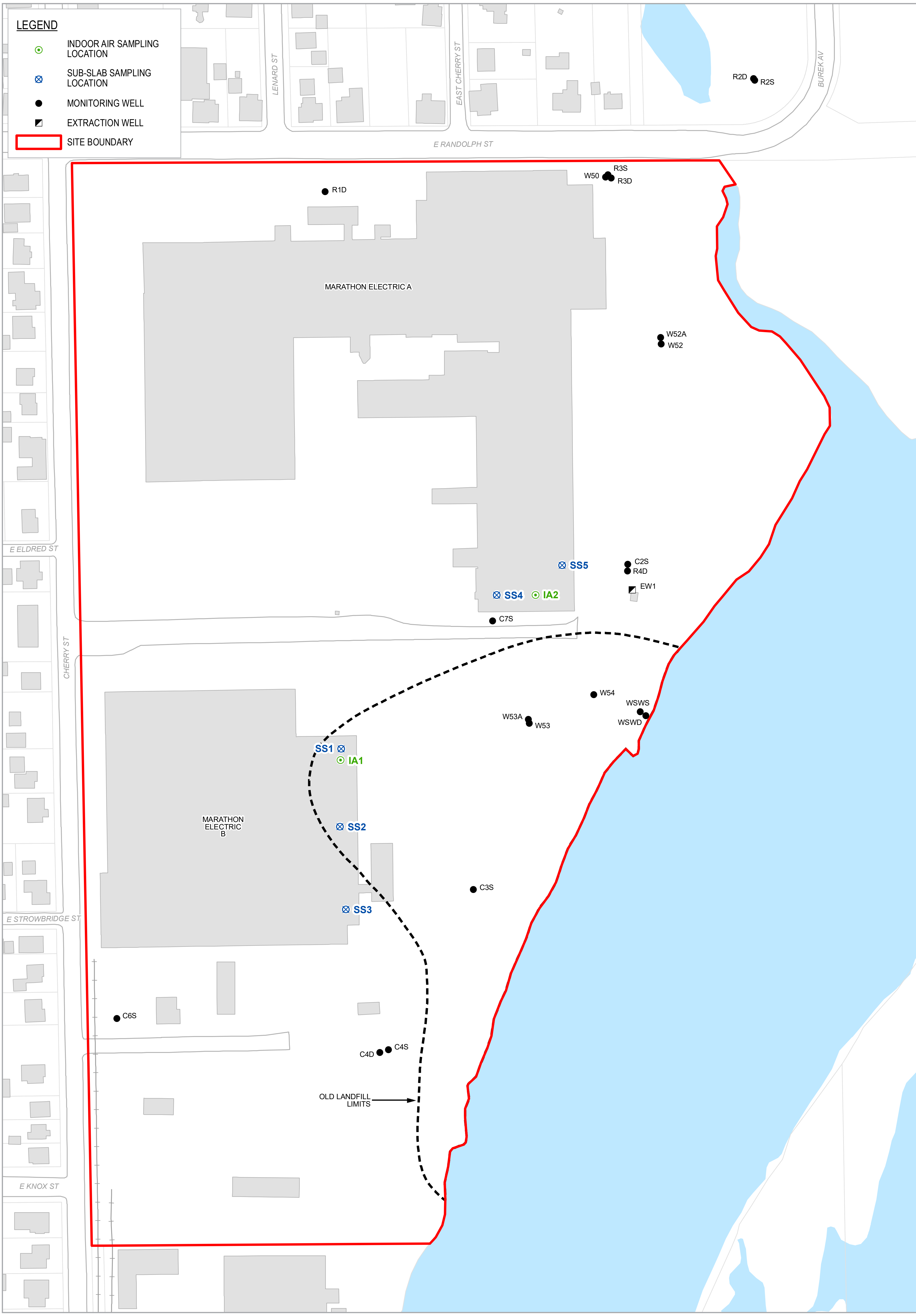

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Grid: NAD 1983 HARN WISCRS Marathon County Feet

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

WEST BANK SUB-SLAB VAPOR AND INDOOR AIR SAMPLE LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/28/2020

FIGURE 4

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Table 1

Groundwater Delineation Sample Results
Vapor Intrusion Evaluation
Wausau Water Supply NPL Site
Wausau, Wisconsin

East Bank	Date	Water Table Depth (ft bgs)	Sample Depth (ft bgs)	Units	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
E1 (Non-res)	3/6/2017	15	15 -19	µg/L	2.4	1.3	3.2	0.45 U	--	--
E2	3/7/2017	25	25-29	µg/L	4.9	**15**	43	0.90 U	--	--
E3 (Non-res)	3/6/2017	20	20-24	µg/L	6.2/6.1	12/13	14/15	0.60 J/0.69 J	--	--
E4	3/7/2017	28	28-32	µg/L	11	4.9	30	**5.4**	--	--
E5	3/7/2017	25	25-29	µg/L	6.0	1.2	5.3	0.45 U	--	--
E6	3/7/2017	25	25-29	µg/L	0.30 U	0.84 J	7.8	1.6	--	--
E7	3/6/2017	26	26-30	µg/L	0.51 J	0.33 U	0.30 U	0.45 U	--	--
E8	3/6/2017	26	26-30	µg/L	0.30 U	0.33 U	0.30 U	0.45 U	--	--
E9	3/6/2017	24	24-28	µg/L	0.30 U	0.33 U	0.30 U	0.45 U	--	--
West Bank										
W1 (Non-res)	3/8/2017	33	33-35	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
W2 (Non-res)	3/9/2017	30	31-35	µg/L	--	1.0	0.30 U	0.45 U	0.35 U	0.31 U
W3	3/9/2017	34	34-38	µg/L	--	0.33 U/0.33 U	0.30 U/0.30 U	0.45 U/0.45 U	0.35 U/0.35 U	0.31 U/0.31 U
W4	3/9/2017	23	23-25	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	2.1
W5	3/9/2017	9	10-12	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
W6	3/9/2017	9.5	10-12	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
W7	3/9/2017	28	29-32	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
Residential Vapor Intrusion Screening Level (10E-05 target risk for carcinogens)				µg/L	**120**	**10**	**--**	**3.0**	**7.6**	**15**
Non-Residential Vapor Intrusion Screening Level (10E-05 target risk for carcinogens)				µg/L	**510**	**42**	**--**	**37**	**34**	**64**

Notes:

15 - indicates VI screening level exceeded
Screening levels are based on USEPA's VISL Calculator with 1.0E-05 additional cancer risk and a 1.0 Hazard Quotient for non-carcinogens

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

East Bank - March 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride
E1 S (Non-res)	3/9/2017	15	8.5 - 9	ug/m3	1,300	9.6	6.3 U	2.0 U
E2 S	3/9/2017	25	8.5 - 9	ug/m3	77	1.6	0.79 U	0.26 U
E2 D	3/9/2017	25	19.5 - 20	ug/m3	120	33	28	0.51 U
E3 S (Non-res)	3/9/2017	20	8.5 - 9	ug/m3	130	76	6.1	0.10 U
E4 S	3/9/2017	28	8.5 - 9	ug/m3	38	0.21 U	0.32 U	0.10 U
E4 D	3/9/2017	28	21.5 - 22	ug/m3	190	21	13	0.26 U
E5 S	3/10/2017	25	8.5 - 9	ug/m3	100	0.99	0.32 U	0.10 U
E5 D	3/10/2017	25	21.5 - 22	ug/m3	160	8.6	0.51	0.10 U
E6 S	3/10/2017	25	8.5 - 9	ug/m3	69	1.8	0.32 U	0.10 U
E6 D	3/10/2017	25	21.5 - 22	ug/m3	750/680	27/26	7.4/7.0	0.68 U
E7 S	3/10/2017	26	8.5 - 9	ug/m3	W	W	W	W
E7 D	3/10/2017	26	21.5 - 22	ug/m3	96	7.2	0.35	0.10 U
E8 S	3/10/2017	26	8.5 - 9	ug/m3	25	0.43 U	0.63 U	0.20 U
E8 D	3/10/2017	26	21.5 - 22	ug/m3	160	17	0.63 U	0.20 U
E9 S	3/10/2017	24	8.5 - 9	ug/m3	160	0.43 U	0.63 U	0.20 U
E9 D	3/10/2017	24	21.5 - 22	ug/m3	170	25	1.2	0.10 U
Residential Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**1,400**	**70**	**--**	**56**
Small Industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**5,840**	**290**	**--**	**930**

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

East Bank - August 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride
E1 S (Non-res)	8/1/2017	15	8.5 - 9	ug/m3	1,700/1,900	24/23	3.4 U/1.2 J	2.7 U/0.74 U
E2 S	8/1/2017	25	8.5 - 9	ug/m3	43	0.75 U	0.95 U	0.74 U
E2 D	8/1/2017	25	19.5 - 20	ug/m3	51	46	39	0.74 U
E3S (Non-res)	8/1/2017	20	8.5 - 9	ug/m3	NA	NA	NA	NA
E4 S	8/1/2017	28	8.5 - 9	ug/m3	25	0.75 U	0.95 U	0.74 U
E4 D	8/1/2017	28	21.5 - 22	ug/m3	2.3 J	1.2 J	0.95 U	0.74 U
E5 S	8/1/2017	25	8.5 - 9	ug/m3	66/64	0.75 U/0.75 U	0.95 U/0.95 U	0.74 U/0.74 U
E5 D	8/1/2017	25	21.5 - 22	ug/m3	170	5.4	0.95 U	0.74 U
E6 S	8/1/2017	25	8.5 - 9	ug/m3	NA	NA	NA	NA
E6 D	8/1/2017	25	21.5 - 22	ug/m3	NA	NA	NA	NA
E7 S	8/1/2017	26	8.5 - 9	ug/m3	W	W	W	W
E7 D	8/1/2017	26	21.5 - 22	ug/m3	410	4.8	0.95 U	0.74 U
E8 S	8/1/2017	26	8.5 - 9	ug/m3	30	1.2 J	0.95 U	0.74 U
E8 D	8/1/2017	26	21.5 - 22	ug/m3	92	10	0.95 U	0.74 U
E9 S	8/1/2017	24	8.5 - 9	ug/m3	230	1.6 J	0.95 U	0.74 U
E9 D	8/1/2017	24	21.5 - 22	ug/m3	220	7.8	0.96 J	0.74 U
Non-industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**1,400**	**70**	**--**	**56**
Small Industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**5,840**	**290**	**--**	**930**

Notes:

NA - Probes E3, E6S, and E6D were removed by road construction prior to the August 2017 sampling event

W - Probe E7S could not be sampled during either sampling event due to water in the probe

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

West Bank - March 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
W-1S (Indust)	3/13/2017	33	8.5 - 9	ug/m3	6.1	0.095 U	0.074 U	0.38 J	0.56
W-1D (Indust)	3/13/2017	33	29.5 - 30	ug/m3	6.4	0.095 U	0.074 U	0.49 J	0.12 J
W-2S (Indust)	3/13/2017	30	8.5 - 9	ug/m3	94	0.16 J	0.12 U	0.74 J	0.0778 J
W-2D (Indust)	3/13/2017	30	26.5 - 27	ug/m3	86	0.18 J	0.093 U	0.21 J	0.46 J
W-3S	3/14/2017	34	8.5 - 9	ug/m3	10	0.095 U	0.074 U	0.25 J	0.19 J
W-3D	3/14/2017	34	30.5 - 31	ug/m3	32	0.13 J	0.074 U	0.34 J	0.13 J
W-4S	3/14/2017	21	8.5 - 9	ug/m3	0.099 J	0.095 U	0.074 U	0.094 U	3.3
W-4D	3/14/2017	21	18.5 - 19	ug/m3	0.13 J	0.095 U	0.074 U	0.094 U	14
W-5S	3/14/2017	9	5.5 - 6	ug/m3	9.0	0.095 U	0.074 U	0.28 J	0.13 J
W-6S	3/14/2017	9.5	5.5 - 6	ug/m3	2.2	0.095 U	0.074 U	0.74	0.35 J
W-7S	3/14/2017	28	8.5 - 9	ug/m3	7.3	0.095 U	0.074 U	0.12 J	<0.073
W-7D	3/14/2017	28	24.5 - 25	ug/m3	1.8	0.095 U	0.074 U	0.10 J	0.10 J
Residential Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**70**	**--**	**57**	**127**	**43**
Large Industrial Screening Level (10-5 Additional Risk) (0.01 attenuation factor)				ug/m3	**880**	**--**	**2,800**	**2,050**	**540**

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

West Bank - August 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
W-1S (Indust)	8/1/2017	33	8.5 - 9	ug/m3	0.77 J/0.75 U	0.95 U/0.95 U	0.74 U/0.74 U	0.94 U/0.94 U	0.73 U/0.73 U
W-1D (Indust)	8/1/2017	33	29.5 - 30	ug/m3	170	0.95 U	0.74 U	4.5 J	1.3 J
W-2S (Indust)	8/1/2017	30	8.5 - 9	ug/m3	160	0.95 U	0.74 U	0.94 U	0.73 U
W-2D (Indust)	8/1/2017	30	26.5 - 27	ug/m3	100	0.95 U	0.74 U	0.94 U	0.73 U
W-3S	8/1/2017	34	8.5 - 9	ug/m3	4.5	0.95 U	0.74 U	0.94 U	0.75 J
W-3D	8/1/2017	34	30.5 - 31	ug/m3	13	0.95 U	0.74 U	0.94 U	0.73 U
W-4S	8/1/2017	21	8.5 - 9	ug/m3	0.75 U/0.75 U	0.95 U/0.95 U	0.74 U/0.74 U	0.94 U/0.94 U	20/14
W-4D	8/1/2017	21	18.5 - 19	ug/m3	65	0.95 U	0.74 U	1.3 J	21
W-5S	8/1/2017	9	5.5 - 6	ug/m3	4.5	0.95 U	0.74 U	0.94 U	0.73 U
W-6S	8/1/2017	9.5	5.5 - 6	ug/m3	W	W	W	W	W
W-7S	8/1/2017	28	8.5 - 9	ug/m3	7.8	0.95 U	0.74 U	0.94 U	0.73 U
W-7D	8/1/2017	28	24.5 - 25	ug/m3	1.8 J	0.95 U	0.74 U	0.94 U	0.73 U
Non-industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**70**	**--**	**57**	**127**	**43**
Large Industrial Screening Level (10-5 Additional Risk) (0.01 attenuation factor)				ug/m3	**880**	**--**	**2,800**	**2,050**	**540**

Notes:

W - Probe W6S could not be sampled during the August 2017 sampling event due to water in the probe
Screening levels are based on USEPA's VISL Calculator with a 10-05 target risk for carcinogens; and a 1.0 Hazard Quotient

Table 3

East Bank Subslab and Indoor Air Lab Results
Wausau Water Supply NPL Site
Wausau. Wisconsin

SUB-SLAB

(Bodenheimer)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
1901 N. 2nd St.	4/4/2017	Subslab	130	11	9.6	0.074 U
1901 N. 2nd St.	7/31/2017	Subslab	7.8	1.4 J	1.0 J	0.074 U
1901 N. 2nd St.	3/27/2018	Subslab	140	56	68	0.074 U
(Hang)						
1905 N. 2nd St.	5/15/2017	Subslab	160	0.18	0.095 U	0.074 U
1905 N. 2nd St.	3/28/2018	Subslab	220	**84**	3.2	0.074 U
(Westberg)						
1909 N. 2nd St.	5/15/2017	Subslab	47	0.40	0.095 U	0.074 U
1909 N. 2nd St.	7/31/2017	Subslab	57	0.86 J	0.095 U	0.074 U
1909 N. 2nd St.	3/27/2018	Subslab	100	8.6	0.095 U	0.074 U
(Viergutz)						
1915 N. 2nd St.	4/4/2017	Subslab	63	3.5	0.095 U	0.074 U
1915 N. 2nd St.	7/31/2017	Subslab	42	1.0 J	0.095 U	0.074 U
1915 N. 2nd St.	3/27/2018	Subslab	65	42	0.095 U	0.074 U
(Krause)						
1917 N. 2nd St.	4/4/2017	Subslab	110	12	0.52	0.086 J
1917 N. 2nd St.	5/15/2017	Subslab	68	12	0.095 U	0.074 U
1917 N. 2nd St.	7/31/2017	Subslab	49	3.3	0.095 U	0.074 U
1917 N. 2nd St.	3/27/2018	Subslab	76	**160**	2.8 J	0.074 U
Sub-slab Residential Screening Level (0.03 attenuation factor)			**1,400**	**70**	**--**	**57**

INDOOR AIR

(Bodenheimer)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
1901 N. 2nd St.	4/4/2017	Basement	0.15 J	0.075 U	0.095 U	0.074 U
1901 N. 2nd St.	7/31/2017	Basement	0.44 J	0.075 U	0.095 U	0.074 U
1901 N. 2nd St.	3/27/2018	Basement	0.38 J	0.15 J	0.095 U	0.074 U
(Hang)						
1905 N. 2nd St.	5/15/2017	1st Floor	0.14 J	0.075 U	0.095 U	<0.074
1905 N. 2nd St.	3/28/2018	1st Floor	0.11 J	0.075 U	0.095 U	0.074 U
(Westberg)						
1909 N. 2nd St.	5/15/2017	1st Floor	0.31 J	0.075 U	0.095 U	0.074 U
1909 N. 2nd St.	7/31/2017	1st Floor	0.28 J	0.075 U	0.095 U	0.074 U
1909 N. 2nd St.	3/27/2018	1st Floor	0.31 J	0.20 J	0.095 U	0.074 U
(Viergutz)						
1915 N. 2nd St.	4/4/2017	1st Floor	1.1	0.33	0.095 U	0.074 U
1915 N. 2nd St.	7/31/2017	1st Floor	0.24 J	0.075 U	0.095 U	0.074 U
1915 N. 2nd St.	3/27/2018	1st Floor	0.65	0.52	0.099 J	0.074 U
(Krause)						
1917 N. 2nd St.	4/4/2017	1st Floor	0.70	1.8	0.42	0.074 U
1917 N. 2nd St.	5/15/2017	1st Floor	0.28 J	0.14 J	0.095 U	0.074 U
1917 N. 2nd St.	7/31/2017	1st Floor	0.56	0.075 U	0.095 U	0.074 U
1917 N. 2nd St.	3/27/2018	1st Floor	0.65	0.86	0.40	0.074 U
(Krause)						
1917 N. 2nd St.	5/15/2017	Basement	1.2	**2.9**	0.68	0.074 U
1917 N. 2nd St.	7/31/2017	Basement	0.38 J	0.28	0.095 U	0.074 U
1917 N. 2nd St.	3/27/2018	Basement	0.99	1.6	0.75	0.074 U
Residential Indoor Air Action Level			**42**	**2.1**	**--**	**1.7**

Note: All units µg/m3

Table 3

East Bank Subslab and Indoor Air Lab Results
Wausau Water Supply NPL Site
Wausau. Wisconsin

SUB-SLAB

(Steffen)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
2108 N 3rd St.	3/27/2018	Subslab	370	**120**	42	0.074 U
(Helke)						
2103 N. 3rd St	4/25/2019	Subslab	1.1U	0.75U	0.95U	0.74U
2103 N. 3rd St	9/24/2019	Subslab	1.1	0.32U	0.40U	0.66U
Sub-slab Residential Screening Level (0.03 attenuation factor)			**1,400**	**70**	**--**	**57**

INDOOR AIR

(Steffen)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
2108 N 3rd St.	3/27/2018	1st Floor	2.1	0.83	0.16 J	0.074 U
2108 N. 3rd St.	4/25/2019	1st Floor	2.4	0.65	0.095U	0.074U
2108 N. 3rd St.	4/25/2019	Basement	3.4	0.71	0.095U	0.074U
(Helke)						
2103 N. 3rd St.	4/25/2019	1st Floor	1.7	0.38	0.095U	0.074U
2103 N. 3rd St.	9/24/2019	1st Floor	0.69	0.039 J	0.095U	0.074U
Residential Indoor Air Action Level			**42**	**2.1**	**--**	**1.7**

Commercial Properties

SUB-SLAB

(Bridge Clinic)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
Bridge Comm. Clinic	4/4/2017	Subslab	3,000	58	7.6 U	5.9 U
Bridge Comm. Clinic	7/31/2017	Subslab	2,700	65	6.7 U	5.2 U
(D&J Rentals 200 E. Wausau Ave.)						
D&J Showroom	4/25/2019	Subslab	740	25	0.095U	0.074U
D&J South Storage	4/25/2019	Subslab	97	15	0.40 J	0.074U
D&J South Storage Dup.	4/25/2019	Subslab	100	16	1.6 J	0.074U
D&J Showroom	9/24/2019	Subslab	1,100	37	0.40U	0.66U
D&J South Storage	9/24/2019	Subslab	240	11	1.1 J	0.074U
D&J South Storage Dup	9/24/2019	Subslab	220	10	1.1 J	0.074U
Small Commercial Sub-slab Screening Level (0.03 attenuation factor)			**6,000**	**290**	**--**	**930**

INDOOR AIR

(Bridge Clinic)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
Bridge Comm. Clinic	4/4/2017	Basement	16	0.44	0.095 U	0.074 U
Bridge Comm. Clinic	7/31/2017	Basement	2.1	0.34	0.095 U	0.074 U
(D&J Rentals 200 E. Wausau Ave.)						
D&J - Showroom	4/25/2019	Basement	0.68	0.098	0.95U	0.74U
D&J - Showroom	9/24/2019	Basement	2.2	0.088	0.04U	0.066U
Small Commercial Indoor Air Action Level			**180**	**8.8**	**--**	**28**

Note: All units µg/m3

Screening Levels and Action Levels are from Wisconsin DNR "WI Vapor Quick Look-Up Table, Indoor Air Vapor Action Levels and Vapor Risk Screening Levels. Based on November 2017 U.S.EPA Regional Screening Levels.

Table 4

Summary of Property Owner Contacts and Sequence of Sub-slab and Indoor Air Sampling
Wausau Water Supply NPL Site
Wausau, Wisconsin

Sampling Event	Date	Properties Contacted to Request Access	Properties Sampled	Properties Not Responding or Declined Access
Round 1	4/4/2017	1901, 1905, 1909, 1915, and 1917 N. 2nd Street, Bridge Comm. Clinic	1901, 1915, and 1917 N. 2nd Street, Bridge Comm. Clinic	1905 and 1909 N. 2nd Street
Round 2	5/15/2017	1905, 1909, and 1917 N. 2nd Street	First sample from 1905 and 1909 N. 2nd St..Second sample from 1917 N. 2nd St..	None
Round 3	7/31/2017	1901, 1905, 1909, 1915, and 1917 N. 2nd Street, Bridge Comm. Clinic	Second sample from 1901, 1909, 1915 N. 2nd St. and Bridge Comm. Clinic. Third sample from 1917 N. 2nd St.	1905 N. 2nd St.
Round 4	3/27/2018	1901, 1905, 1909, 1915, and 1917 N. 2nd, Bridge Comm. Clinic and 2108 N. 3rd St.	Second sample from 1905 N. 2nd, Third samples from 1901, 1909, 1915 N. 2nd St.. Fourth sample from 1917 N. 2nd. Plus first sample from 2108 N. 3rd St.	None
Round 5	4/25/2019	2103, 2105, 2106, 2108 N. 3rd St, Thrive Foodery, D&J Rentals	2108 N. 3rd (second sample), 2103 N. 3rd, D&J Rentals	No responses from 2105 N. 3rd and Thrive Foodery. 2106 N. 3rd refused access
Round 6	9/24/2019	2103, 2105, 2106, 2108 N. 3rd St, Thrive Foodery, D&J Rentals	Second samples from 2103 N. 3rd and D&J Rentals	No responses from 2105 N. 3rd and Thrive Foodery. 2106 N. 3rd refused access

Table 5

West Bank Sub-slab Vapor and Indoor Air Results
Wausau Water Supply NPL Site
Wausau, Wisconsin

Sub-slab Regal - March 2017	**Date**	**Units**	**Trichloroethene**	**c-1,2-Dichloroethene**	**Vinyl chloride**	**Carbon tetrachloride**	**Chloroform**
SS-1 (north side Building B)	3/13/2017	ug/m3	270	1.3 J	0.37 U	0.47 U	0.40 J
SS-2 (middle Building B)	3/13/2017	ug/m3	**9,400**	150	21 U	1,200	220
SS-3 (south side Building B)	3/13/2017	ug/m3	0.78	0.95 U	0.74 U	0.62	0.17 J
SS-4 (southeast side Building A)	3/13/2017	ug/m3	220	0.99 J	0.25 U	5.3	1.5
SS-5 (southeast side Building A)	3/13/2017	ug/m3	**4,800**	17 U	13 U	17 U	41 J
Sub-slab Large Industrial Screening Level (0.01 attenuation factor)			**880**	**--**	**2,800**	**2,000**	**530**

Indoor Air Regal - March 2017							
Indoor Air - Building B	3/13/2017	ug/m3	1.6	0.095 U	0.074 U	0.44 J	0.15 J
Indoor Air - Building A	3/13/2017	ug/m3	0.82	0.095 U	0.074 U	0.42 J	0.14 J
Industrial Indoor Air Action Level			**8.8**	**--**	**28**	**20**	**5.3**

Outdoor Air near Building B	3/13/2017	ug/m3	0.075 U	0.095 U	0.074 U	0.41 J	0.093 J

Table 5

West Bank Sub-slab Vapor and Indoor Air Results
Wausau Water Supply NPL Site
Wausau, Wisconsin

Sub-slab Regal - August 2017	Date	Units	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
SS-1 (north side Building B)	8/1/2017	ug/m3	280	1.3 J	0.74 U	0.94 U	0.73 U
SS-2 (middle Building B)	8/1/2017	ug/m3	**15,000**	260	43 U	1,800	470
SS-3 (south side Building B)	8/1/2017	ug/m3	0.75 U	0.95 U	0.74 U	5.5	0.73 U
SS-4 (southeast Building A)	8/2/2017	ug/m3	9.4	0.95 U	0.74 U	0.94 U	0.73 U
SS-5 (southeast Building A)	8/1/2017	ug/m3	**4,900**	15 U	12 U	15 U	50 J
Sub-slab Large Industrial Screening Level (0.01 attenuation factor)			**880**	**--**	**2,800**	**2,000**	**530**

Indoor Air Regal - August 2017	Date	Units	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
Indoor Air - Building B	8/1/2017	ug/m3	0.075 U	0.095 U	0.074 U	0.41 J	0.15 J
Indoor Air - Building A	8/1/2017	ug/m3	0.17 J	0.095 U	0.074 U	0.45 J	0.14 J
Industrial Indoor Air Action Level			**8.8**	**--**	**28**	**20**	**5.3**

Outdoor Air near Building B	8/1/2017	ug/m3	0.075 U	0.095 U	0.074 U	0.44 J	0.14 J

Notes:

4,800 - Result exceeded applicable screening level

J - Estimated value

Screening Levels and Action Levels are from Wisconsin DNR "WI Vapor Quick Look-Up Table, Indoor Air Vapor Action Levels and Vapor Risk Screening Levels. Based on November 2017 U.S.EPA Regional Screening Levels.

Appendix B

Quality Assurance Objectives

Appendix B Quality Assurance

1. Data Quality Objectives

The QA objective for this project is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and laboratory reporting that will provide results that can be used to make decisions regarding potential risks related to soil vapor intrusion of commercial/industrial and residential buildings. Shallow groundwater contaminants will be further delineated, vadose zone vapor will be characterized, and buildings will be assessed to determine occupancy and construction features.

The data will be used to support decisions about whether additional groundwater delineation is needed, if the vapor characterization area should be expanded, or if sub-slab and indoor air sampling should be conducted; and whether vapor intrusion mitigation should be pursued in buildings.

1.1 Precision

1.1.1 Field Precision Objectives

Field precision for measurements associated with groundwater monitoring and vapor sampling will be assessed through the collection and measurement of duplicate samples or calibration check solutions at a frequency of one per ten groundwater samples. The precision control limits for field measurements obtained during the field investigation activities are summarized in the field investigation SOPs in Appendix D.

1.1.2 Laboratory Precision Objectives

Precision in the laboratory will be assessed through the calculation of relative percent differences (RPDs) for replicate/duplicate samples. The equations for RPD calculations are presented in the laboratory SOP for each method, which are provided in Appendix B.

1.2 Accuracy

1.2.1 Field Accuracy Objectives

Groundwater sampling accuracy in the is assessed through the use of field and trip blank samples and is ensured by observing all sample handling procedures, preservation requirements, and holding time periods. Accuracy of field measurements associated with groundwater monitoring will be assessed by analyzing calibration check solutions. Accuracy control limits for the field measurements obtained during the field investigation activities are summarized in the field investigation SOPs in Appendix D.

1.2.2 Laboratory Accuracy Objectives

Laboratory accuracy will be assessed by determining percent recoveries from the analysis of matrix spikes or laboratory control samples (LCS). The accuracy of the organics analyses will be monitored through the analysis of surrogate compounds. Surrogate compounds are added to each sample, standard, blank, and QC sample prior to sample preparation and analysis. Surrogate compounds are not expected to be found occurring naturally in the samples, but behave analytically similar to the compounds of interest. Consequently, surrogate compound percent recoveries will provide information on the effect that the sample matrix exhibits on the accuracy of the analyses. Corrective measures, if needed, are described in the method SOPs (Appendix B).

1.3 Completeness

1.3.1 Field Completeness Objectives

Field completeness is a measure of the amount of valid field measurements obtained from all the measurements taken during the project. The equation for completeness is presented in the laboratory SOPs. The field completeness objective for this project will be 90 percent or greater.

1.3.2 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of valid laboratory measurements obtained from all the measurements taken during the project. The laboratory completeness objective for this project will be 95 percent or greater.

1.4 Representativeness

1.4.1 Measures To Ensure Representativeness of Field Data

Representativeness is dependent upon the proper design of the sampling program. Representativeness will be ensured by following the procedures described in this work plan and using proper sampling techniques.

1.4.2 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicate samples. The sampling network is designed to provide data representative of Site conditions.

1.5 Decision Rules

1.5.1 Decision Rule Objectives

If detectable concentrations of COPCs are detected in groundwater, the data will be screened using EPA's groundwater to indoor air VISL Calculator for residential and/or commercial/industrial scenarios. If detectable concentrations of COPCs are detected in soil vapor, the data will be compared to EPAs VISL for soil vapor to indoor air utilizing the EPA-recommended attenuation factors for residential and/or commercial/industrial scenarios. If COPC vapor concentrations exceed the screening levels, additional vapor monitoring will be conducted, including potential sub-slab and indoor air.

If the COPCs are detected in indoor air at concentrations above the action levels and corresponding outdoor ambient air results do not contain COPCs, then vapor mitigation may be required.

If COPCs are not detected in sub-slab vapors or indoor air (including crawl spaces) at concentrations above the action levels, then vapor mitigation will not be pursued.

1.6 Comparability

1.6.1 Measures to Ensure Comparability of Field Data

Comparability is dependent upon the proper design of the sampling program and will be ensured by using proper sampling techniques.

1.6.2 Measures to Ensure Comparability of Laboratory Data

The laboratory data to be obtained during the VI field investigation activities will be comparable to previous data when similar sampling and analytical methods are used. Comparability is also dependent on similar QA objectives.

1.7 Level of Quality Control Effort

Trip blank, equipment blank, field duplicate, matrix spike, method blank, and laboratory duplicate samples will be analyzed to assess the quality of the laboratory's data resulting from the field sampling and analysis program for the VI field investigation. Trip blank samples are used to assess the potential for contamination of samples resulting from contaminant migration during sample shipment and storage. Trip blank samples pertain only to aqueous VOC samples. Trip blank samples that consist of ultra-pure water are prepared in sample containers at the laboratory prior to the sampling event and are kept with the groundwater samples collected throughout the sampling event. Trip blank samples will be packaged for shipment with other groundwater samples and submitted to the laboratory for analysis. Trip blank sample containers will not be opened prior to analysis at the laboratory.

Method blank samples are generated within the laboratory and are used to assess contamination resulting from laboratory procedures. Field duplicate samples are analyzed to assess overall sampling and analytical reproducibility. Groundwater field duplicate samples are collected by alternately filling the sample containers for each parameter to be analyzed from the same sampling device. Vapor duplicate samples are collected by using a T-connector to join two vacuum canisters to one vapor source.

Matrix spikes provide information about the effect of the sample matrix on the preparation and measurement methodology. Matrix spike samples generally are analyzed in duplicate and are referred to as matrix spike/matrix spike duplicate (MS/MSD) samples. MS/MSD samples are investigative samples which have been fortified (spiked) by the laboratory with a known amount of the analyte(s) of interest. MS/MSD analysis is not applicable to air or vapor samples. Aqueous MS/MSD samples must be collected at triple the usual volume for VOCs.

The level of the QC effort for groundwater samples will be one equipment blank sample and one field duplicate sample for every 10 or fewer samples. One VOC trip blank sample consisting of laboratory-prepared ultra-pure water will be included along with each shipment of groundwater VOC samples. One MS/MSD sample will be submitted with every 20 or fewer samples collected for organic analyses.

The level of QC effort for field pH and conductivity measurements will include periodic calibration verification of the instrument using standard solutions of known pH and conductivity. Temperature measurements are obtained with pH and/or conductivity and field calibration is neither possible nor practical.

The level of QC effort for the vapor sampling program will be one field duplicate sample for every 20 or fewer vapor samples. Field duplicate samples will be collected by using a T-connector to split the sample into two canisters. Field blank and trip blank samples will not be collected because the canisters and flow controllers will be individually cleaned and certified by the laboratory prior to being shipped to the project location. In addition, pre-shipping and post-shipping vacuum measurements, post-sampling vacuum measurements in the field and at the laboratory, and the use of a tracer (sub-slab vapor sampling only) will indicate if sample integrity has been compromised during sampling or shipping. Consequently, field and trip blank sample data will not be required to evaluate sample integrity.

Table B.1

Targeted Reporting and Detection Limits
Vapor Intrusion Evaluation Work Plan
Wausau Water Supply Superfund Site
Wausau, Wisconsin

Chemical	Soil Probe and Sub-slab Targeted Reporting Limit (ug/m^3) [1]	Proposed Residential Sub-slab Action Level (ug/m^3)	Proposed Commercial/Industrial Sub-slab Action Level (ug/m^3)
Tetrachloroethene	5.4	360	1575
Trichloroethene	2.2	16	100
cis-1,2- Dichloroethene	3.2	NA	NA
Vinyl chloride	2	7.7	93
Carbon Tetrachloride	5	16	69
Chloroform	3.9	4.1	18

Chemical	Indoor Air / Ambient Air Targeted Method Detection Limit (ug/m^3) [1]	Proposed Indoor Air Residential Action Level (ug/m^3)	Proposed Indoor Air Commercial/Industrial Action Level (ug/m^3)
Tetrachloroethene	0.11	11	47
Trichloroethene	0.075	0.48	3.0
cis-1,2- Dichloroethene	0.10	NA	NA
Vinyl chloride	0.074	0.17	2.8
Carbon Tetrachloride	0.09	0.47	2.0
Chloroform	0.073	0.12	0.53

Note:

(1) - Targeted reporting and detection limits are presented for guidance and may not be achievable for all samples as a result of matrix interferences or high concentrations of target and non-target compounds.

Appendix C

Field Protocols and Field Sampling SOPs

Appendix C General Field Protocols

1.1 Decontamination Procedures

1.1.1 Drilling Equipment

Upon mobilization to the Site and prior to subsurface investigation activities, the DPT drill rig and equipment will be thoroughly cleaned to remove oil, grease, mud, and other foreign matter. Furthermore, all cutting bits, augers, probes, rods, samplers, drill steel, buckets, and associated equipment will be decontaminated prior to their use at subsequent testing locations.

Equipment decontamination will be accomplished by flushing and wiping the components to remove all visible sediments followed by:

1. High pressure washing with potable water to remove particulate matter and surface films
2. Rinsing thoroughly with potable water and Alconox™ or similar low-phosphate detergent. If necessary, a bermed and plastic-lined decontamination pad will be constructed for cleaning of the drilling rig and equipment. The decontamination pad will facilitate capture of cleaning fluids for proper management. Collected decontamination fluids will be managed as described in Section 2.1.4 below.

1.1.2 Sampling Equipment

Sampling equipment will be decontaminated before and after field utilization during the advancement of soil borings or the installation of temporary monitoring wells to prevent cross-contamination between locations. Whenever practicable, dedicated sampling equipment will be used to minimize the potential for sample cross-contamination.

Decontamination of equipment used for collection of samples for laboratory analyses will be performed as follows:

1. Wash with potable water and Alconox™, or similar low-phosphate detergent using a brush, as necessary, to remove all visible foreign matter
2. Rinse thoroughly with potable water
3. Rinse thoroughly with distilled water
4. Allow the equipment to air dry on a clean plastic sheet as long as possible. Following the final rinse, equipment will be visually inspected by GHD field personnel to verify that it is free of soil particulates and other solid material that could contribute to possible sample cross-contamination. Decontamination fluids will not be recycled between samples and will be managed as waste material as described in Section 2.1.4.

1.2 Field Documentation

A dedicated field logbook will be utilized for this project to detail the field activities conducted by GHD Services Inc. (GHD) during investigation activities. The field logbook will be a bound document with consecutively numbered pages. The entries for each day will commence on a new page, which will be dated and signed by the GHD field technician. All entries will be made only in indelible ink. Corrections will be made by marking through the error with a single line, to remain legible, and initialing this action followed by writing the correction.

The dedicated field logbook will be maintained by a GHD Site representative. Upon completion of the fieldwork or during periods when fieldwork is not scheduled, the field logbooks will be maintained in GHD's St. Paul, Minnesota office. Ultimately, after completion of all stages of fieldwork, the logbooks will be maintained in the permanent project file in GHD's St. Paul office.

The following information will be recorded in the field logbook or field data forms for each sample collected:

1. Site location identification
2. Unique sample identification number
3. Sample location
4. Date and time (in 2400-hour time format) of sample collection
5. Weather conditions
6. Designation as to the type of sample (groundwater, vapor, etc.)
7. Designation as to the means and methodologies for collection (grab, bailer, etc.)
8. Name of the sampler
9. Analyses to be performed on collected samples
10. Any other relevant comments such as odor, staining, texture, filtering, preservation, etc.

Records of equipment maintenance and calibration, and observations on equipment performance will also be recorded in the field logbook. Alternatively, GHD may utilize standard forms to record information such as records of equipment maintenance, stratigraphy, well construction, and well development.

1.3 Waste Handling

Investigation derived wastes (IDW) generated during the investigation will include general refuse, soil samples, decontamination fluids, and temporary well purging fluids. General refuse, including plastic sheeting, buckets, paper bags, etc., will be disposed of in waste receptacles. Daily refuse and personal protective equipment (PPE) will be collected in plastic bags and disposed of as necessary to keep the Site area clear of debris and refuse.

IDW generated during Site investigation activities will be placed into DOT approved 55-gallon drums and staged on Site at a location at the Site designated by the project management team. Decontamination fluids, purged groundwater, and sampling fluids will be purged directly into 55-gallon drums and staged at the designated location.

1.4 Utility Clearance

Prior to performing subsurface investigation activities, including the installation of soil borings or monitoring wells, GHD will contact the one-call system through the Wisconsin Digger’s Hotline (WDH) to locate and identify any subsurface utilities and obstructions. If necessary, a Site visit and review with applicable City engineering and utility offices may be warranted. If GHD requests WDH to locate public utilities and they are not located prior to performing drilling activities, GHD will immediately notify the WDH to obtain the locate status. If necessary, an emergency locate will be requested. No investigation activities will begin unless the public utilities have been properly marked. If private utilities are potentially present in the vicinity of the proposed investigation locations, GHD will subcontract a private utility locator to locate and mark the private subsurface utilities.

1.4.1 Sample Handling and Documentation Protocols

Sample Labeling

The samples will be labeled with a unique sample number that will facilitate tracking and cross-referencing of sample information. The sample identification system to be used is described as follows:

Example: GW-MMDDYY-XX-001

Where:

> GW - designates types of sample (GW-groundwater, SG-soil gas, SS-sub-slab, IA-indoor air, and AA-ambient air)
>
> YYMMDD - designates date of collection presented as year/month/day
>
> XX - designates sampler's initials
>
> 001 - designates sequential number starting with 001 at the start of the project

Field blank and field duplicate sample will also be identified with a unique sample number, consistent with the numbering system described above, to prevent laboratory bias of field QC samples.

1.4.2 Sample Containers and Handling

All samples will be placed in appropriate laboratory supplied sample containers, labeled, and properly sealed. Sample labels will include sample number, date of collection, and analyses to be performed. Groundwater samples will be carefully packed into shipping coolers by the use of bubble wrap or similar packing material and kept on ice while in GHD's custody. Samples will be shipped by commercial courier to the project laboratory. Samples collected on a Saturday, Sunday, or holiday will be stored on ice in coolers, sealed, and kept under surveillance by a GHD representative. Prior to shipment, the GHD representative will ensure that the samples have been stored appropriately and have not been tampered with.

Chain-of-custody seals will be placed on the front and back of each shipping cooler prior to shipment to secure the lid and provide evidence that the samples have not been tampered with during shipping. Clear tape will be placed over the seals to ensure that they are not accidentally broken during shipment. The GHD sampler will be responsible for packing, sealing, and delivering the sample coolers to an overnight courier. Upon receipt of the cooler at the laboratory, the cooler will be inspected by the laboratory sample custodian. The sample custodian will note the condition of the cooler and seal on the chain-of-custody form. The sample custodian will document the date and time the cooler is received and sign the chain-of-custody forms. The sample custodian will check the contents of the cooler with those samples listed on the chain-of-custody form. If damage or discrepancies are noticed, they will be recorded in the remarks column of the chain-of-custody form, dated and signed. Discrepancies will be reported to the laboratory supervisor who will inform the laboratory manager and quality assurance (QA) officer. Sample disposal will be the responsibility of the laboratory.

1.4.3 Chain-Of-Custody Forms

Chain-of-custody records will be used to track samples from the time of sampling to the arrival of samples at the laboratory. Each shipping container sent to the laboratory will contain an individual chain-of-custody form. The chain-of-custody form consists of four copies, which are distributed to the sampler, contract laboratory, and GHD's office files. The samplers will maintain their copies while the other three copies will be enclosed in a waterproof enclosure within the sample shipping container. Upon receipt of the samples, the laboratory will complete the remaining copies. The laboratory will maintain one copy for its records. The executed original will be returned to GHD with the data deliverables package.

1.5 Quality Control

A summary of the QA/QC samples scheduled for this project is provided on Table B.1 in Appendix B. Details regarding the media-specific QA/QC sampling protocols are provided in the sections below.

1.5.1 Groundwater Sampling

Groundwater QA/QC samples will include a field duplicate, equipment blank, trip blank, and matrix spike/matrix spike duplicate (MS/MSD). The QA/QC samples will be collected during groundwater sampling activities and analyzed to assess the quality of the data resulting from the field sampling program. Equipment and trip blanks will consist of analyte-free water and will be submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field-sampling program.

Equipment blank samples will be analyzed to document that decontamination procedures are not causing cross-contamination between samples. Equipment blank samples will consist of pouring distilled or deionized water over precleaned sampling equipment and into laboratory supplied sample containers. Trip blanks are used to assess the potential for contamination of VOC samples due to contaminant migration during sample shipment and storage. Field duplicate samples are analyzed to check for sampling and analytical precision. Matrix spikes provide information about the effect of the sample matrix on the preparation and measurement methodology. All matrix spikes are performed in duplicate.

The QC effort for this investigation will include the collection of one groundwater field duplicates and one equipment blank per 10 groundwater samples. One VOC trip blank sample consisting of water purged with an inert gas will be prepared by the laboratory and will be included along with each shipment of aqueous VOC samples. VOC trip blanks will be preserved by the laboratory in the same manner as the investigative samples. This investigation will also include the collection of MS/MSD samples. MS/MSD water samples will be collected at a frequency of one per 20 groundwater samples. MS/MSD samples will be collected at triple the volume for VOCs.

1.5.2 Vapor Probe/Sub-Slab/Indoor Air QC Samples

The QC effort for the proposed scope of vapor investigations will include the collection of one duplicate indoor air sample, and one duplicate sub-slab sample. Should additional vapor sampling events occur in the future, these samples will be collected on a 1 per 20 environmental samples.

The QA/QC samples will be collected using laboratory provided vacuum canisters and preset flow regulators. The purpose of collecting the ambient air sample is to screen out potential background contaminant sources during the collection of indoor air samples.

GHD Field Training Manual

Section 19.0
Indoor Air Sampling Standard Operating Procedures
Additional Text

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Please adhere to the following Quality System training requirements:

- Employees who are required to conduct a specific field activity must be properly certified to do the work.
- This involves reviewing the SOP and completing the online training course and exam.
- Employees must also conduct this field work under supervised conditions on at least three occasions, and must be certified by a qualified mentor. Only then can an employee conduct a specific field activity on their own. This is documented on a Field Method Training Record (QSF-021).
- Complete the QSF-021 and forward it to trainingrecords-northamerica@ghd.com.

Table of Contents

19. Indoor Air Sampling Standard Operating Procedures 1

19.1 Introduction 1

19.1.1 Prior Planning and Preparation 1
19.1.2 Safety and Health 1
19.1.3 Quality Assurance/Quality Control 2

19.2 Indoor Air Sampling Procedures 3

19.2.1 QA/QC Activities 3
19.2.2 Prior Planning and Preparation 3
19.2.3 General Field Procedures 4
19.2.4 Indoor Air Sampling Protocol 4
19.2.4.1 Physical Building Survey 5
19.2.4.2 Indoor Air Sample Collection Procedure 5
19.2.5 Field Instrumentation Calibration 8
19.2.6 Data Review and Validation 8

19.3 References 9

Forms Index

SP 27 Building Physical Survey Questionnaire

SP 28 Indoor Air Sampling Field Data Sheet

SP 29 Indoor Air Sampling Instructions to Building Occupants

Appendices

Appendix B Radiello® Indoor Air Sampling Protocols & Sampler Information

19. Indoor Air Sampling Standard Operating Procedures

19.1 Introduction

The procedures described herein pertain to the sampling of indoor air to evaluate the potential presence of volatile organic compounds (VOCs) in indoor air. VOCs can be present in a building's breathable air space from background sources such as glues, adhesives, construction materials, degreasers, cleaning products, aerosols, or organic vapor migration from beneath the structure (i.e., vapor intrusion) as a result of subsurface soil or groundwater impacts. The protocol presented herein consists of conducting a physical survey of the building in conjunction with interviewing building occupants, followed by collecting indoor air samples using Summa™ canisters and/or other applicable methods (i.e., passive samplers).

19.1.1 Prior Planning and Preparation

When designing and constructing the indoor air sampling program the following questions should be considered:

1. What is the purpose of the indoor air sampling?
2. What are the potential health and safety hazards?
3. What kinds of analyses are required (e.g., VOCs, petroleum hydrocarbon fractions)?
4. What type of building will be sampled (e.g., residential, commercial)?
5. What is the length of time over which the indoor air samples must be collected (e.g., 8 hours, 24 hours)?
6. Are there any potential background sources of the contaminants of concern?
7. Is the building occupied or vacant?
8. Has the HVAC system been in operation prior for 24 to 48 hours prior to the sampling event?
9. Where will the samples be collected from within the building?
10. Will the selected analytical method provide detection limits below the applicable screening levels?

> Note: If field staff are not aware of and able to answer all of the above noted questions before undertaking work in the field, the work plan must be reviewed in detail with the Project Coordinator/Manager.

19.1.2 Safety and Health

GHD is committed to conducting field activities with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP) Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a JSA to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

19.1.3 Quality Assurance/Quality Control

Quality assurance and quality control procedures should be implemented in every step of the assessment process to ensure the collection of data of acceptable quality. A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate an efficient site investigation.
- Allow for monitoring of staff and subcontractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 19.2.1.

19.2 Indoor Air Sampling Procedures

19.2.1 QA/QC Activities

The level of the QA/QC effort may include:

- A field duplicate.
- A trip blank (typically not required when using Summa canisters – however confirm with local regulatory guidance).
- Outdoor ambient (upwind - background).
- Laboratory certification (individual clean can or batch certification).

Consult appropriate regulatory agency guidance documents and the site-specific work plan for minimum required QA/QC. Applicable and current state and federal guidance for QA/QC indoor air sampling requirements take precedence over the protocols outlined herein. In general, the QA/QC protocols presented herein should be adhered to when state or federal guidance does not exist, or does not, specify QA/QC procedures, types, or frequencies. Field blank and field duplicate samples are analyzed to assess the quality of the data resulting from the field sampling program. A trip blank consisting of an unused Summa™ canister submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field sampling program. The trip blank sample will be analyzed to check for procedural contamination at the Site, which may cause sample contamination.

One field duplicate sample will be obtained for each day of sampling or from at least 10 percent of the samples obtained. The duplicate sample will be collected by using a splitter with separate sampling tubes connecting the splitter to two Summa™ canisters. Duplicate samples will be analyzed to check for sampling and analytical reproducibility. An extra Summa Canister should be considered in case of a faulty canister, gauge, or flow controller. The extra canister, if not needed, could be used as an additional duplicate sample.

An outdoor ambient air sample should be considered for QA/QC purposes to evaluate the potential presence and magnitude of constituent of concern concentrations present in background air in comparison to indoor air sampling results.

The level of QA/QC effort provided by the project laboratory for the samples analyses should correspond to the level of QA/QC effort specified in "The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis" (U.S. EPA, 1988).

19.2.2 Prior Planning and Preparation

The following will be considered prior to indoor air sampling:

1. Review the work program, project documents and the HASP requirements with the Project Coordinator/Project Manager.
2. Complete a Field Equipment Requisition Form (QSF-014). Assemble all equipment and supplies required.
3. Confirm the number of samples, their locations, and analyses with PM prior to completing a Simplified Scope of Work (SSOW).

4. For the laboratory analysis, contact the GHD chemistry group to coordinate:
   - QA/QC requirements.
   - SSOW (Simplified Scope of Work).
   - Laboratory selection (accreditation required).
   - Sample container delivery (be aware of hold-times).
   - Required sampling protocol, in addition to the protocol presented here.
   - Sample shipping details.
   - Duration of sampling (for time-weighted flow controllers).
5. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work QSF-031 for U.S. Work) is necessary for all Vendors who complete field services. Prior to mobilization, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
6. Discuss with property owner/manager the expectations for the sampling event. Ensure the property owner/manager notifies the tenant/employees of proposed sampling.
7. Weather conditions at the time of sampling. Changing weather conditions during the day indoor air samples were collected should be recorded in field logbook.

19.2.3 General Field Procedures

The following indoor air collection procedure outlines the procedure used by GHD in assessing the vapor intrusion pathway. The typical series of events that will take place are:

1. Sample location identification/inspection.
2. Indoor and outdoor air monitoring.
3. Field notes completion, review, checking.
4. Prepare samples for laboratory shipment.

Sample Location Identification/Inspection

Once at the site and prior to indoor air sampling, confirm that the sample location (i.e., indoor air location) has been correctly identified and located.

If it is necessary to relocate any proposed sample locations, the project coordinator must be notified and an alternate location will be selected and approved in the same manner. Most regulatory agencies require indoor air sample locations to be located within a central area of the room of the structure.

19.2.4 Indoor Air Sampling Protocol

The following sections describe the protocol for indoor air sampling. The first step of the procedure is the physical building survey as described in Section 19.2.4.1. The sampling procedure is described in Section 19.2.4.2.

19.2.4.1 Physical Building Survey

A physical survey will be conducted of the buildings to be sampled. The physical survey will be conducted in conjunction with interviewing the occupants and/or current owner of the buildings. It is highly recommended that the survey and interviews be conducted a minimum of 48 hours prior to sampling. The purpose of the physical survey is to obtain data that will allow a qualitative assessment of factors that potentially could influence indoor air quality. In addition, chemicals or products, which have the potential to affect the results of the indoor sampling, should be removed from the building to the extent feasible.

The physical survey includes collecting data on aspects of the building configuration/use(s) such as the following:

- Building layout.
- Foundation construction (e.g., slab-on-grade) and condition.
- Attached garages.
- Utility entrances into the building.
- Ventilation system design and operation.
- Presence of foundation sump.
- Building materials (e.g., recent carpeting/linoleum and/or painting).
- Location of laundry facilities, etc.

The physical survey should also include collecting data related to occupant lifestyle choices and/or work environment that could potentially influence indoor air quality such as the following:

- Storage or use of cleaning products, aerosol consumer products.
- Presence of recently dry-cleaned clothes or household items.
- Storage or use of solvents, paints, and/or petroleum hydrocarbon products.
- Smoking, etc.

The physical survey should be documented by completing the attached SP 27 – Building Physical Survey Questionnaire. It is recommended that a field drawing of the building be generated during the initial survey. Photographs should be collected to support the field drawing. For sampling at commercial and industrial properties, inquire property owner/manager if a Right-to-Know program exists for employees. Request copies of material safety data sheets (MSDS).

19.2.4.2 Indoor Air Sample Collection Procedure

Air samples will be collected from the buildings in the primary living and/or working areas of the building at locations considered representative of the breathing space. For buildings that are slab-on-grade construction, a minimum of 1 indoor air sample will be collected per floor of the building (e.g., a slab-on-grade house with two levels would have 2 samples collected – 1 from each floor). For buildings with a basement, a minimum of 1 indoor air sample will be collected from each level of the building including the basement. An outdoor ambient air sample should be collected contemporaneously with the indoor air sampling activities from an upwind location.

Summa™ Canister Method:

The indoor and outdoor ambient air samples will be collected using a Summa™ canister (6-litre capacity) equipped with a critical orifice flow-regulation device sized to allow the collection of an air sample over the selected time period (e.g., 24-hours). The critical orifice flow-regulation device must be supplied and calibrated by the laboratory selected to conduct the sample analysis.

To the extent possible, the indoor air samples should be collected with windows and building entry/exit doors closed. A closed (no circulation) condition should represent appropriately conservative (worst-case) conditions. If possible, windows and building entry/exit doors should be kept closed for a period of at least 24 hours prior to sample collection. Likewise, ingress and egress activities should be minimized. Heating, ventilation, and air conditioning (HVAC) systems should be operated normally for the season and time of day. During colder months, heating systems should be operating for at least 24 hours prior to the scheduled sampling event to maintain normal indoor temperatures above 65°F (18°C) before and during sampling. During summer months, air conditioners typically would be operating under closed windows/building entry/exit doors conditions, and the operation of an air conditioner can be allowed during sample collection. This would be representative of season-specific ventilation conditions, and within the expected parameters of operation of the building. Care should be taken to deploy the Summa™ canisters away from the direct influence of any blowing or forced air vents (e.g., those emanating from a window-style air conditioning unit or central air conditioning vents).

The indoor air sampling procedure is described as follows:

- Indoor air samples should be collected from an occupied area and as close as practical to the center of the area, but away from high traffic areas to minimize the potential for disturbances during sample collection. Typically, sample canisters should be located between 1 to 1.5 metres (m) or 3 to 4 feet above floor level for adults and at lower sampling heights if the predominant receptors are children, such as in a daycare center or school.
- For each outdoor ambient air sample, an upwind location should be selected. The outdoor ambient air sample should be collected a minimum of 1 m or 3 feet above grade and secured to minimize the potential for disturbance of the canister from weather effects.
- Air sample canisters should be labeled with a unique sample identification number. Both the sample number and the sample location information should be recorded in the project's field logbook. A bound field logbook and/or SP 28 – Indoor Air Sampling Field Data Sheet should be maintained to record all indoor air sampling data.
- A vacuum gauge must be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection. These pressures must be recorded in the field logbook. The vacuum gauge must be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory.
- The critical orifice flow controller must be installed, as supplied by the laboratory, on the canister and the canister must be opened fully at the beginning of sample collection period and start time. The start and finish times must be recorded in the bound field logbook.
- At the start and the end of the sampling period, a portable photoionization detector (PID) should be used to screen for VOC vapors in the sample area. Ideally, a low level, parts per billion (ppb), PID meter should be used during the building survey; and prior to, and during, the indoor

air sampling events. Results of the PID monitoring are to be recorded in the bound field logbook and SP 28 – Indoor Air Sampling Data Sheet.

- Equipment serial numbers, sampler name, calibration records, and any comments must also be recorded with the field logbook.
- Barometric pressure, outdoor ambient temperature, and interior temperature readings should be recorded at the start and completion of sampling. Data may be collected directly from field instrumentation or obtained via online sources (e.g., local NOAA weather station database).
- Following equipment setup, any building occupant(s) should be given the list of instructions to follow while the Summa™ canister sample is being collected in the building. The instructions are listed in SP 29 - Indoor Air Sampling Instructions to Building Occupants.
- The canister valve must be closed fully at the end of the sample period (e.g., after 24 hours) and the sample completion time recorded on the field data sheet. If there is evidence of canister disturbance during the sample collection, this should be recorded.
- The Summa™ canister vacuum must be measured immediately after canister retrieval at the end of the sample period and recorded on the field data sheet. Any sample where the canister reached atmospheric pressure (i.e., no vacuum), the sample should be considered for rejection and the canister returned for cleaning. The minimum residual vacuum required to be considered a valid sample may be dictated by regulatory guidance (generally at least 5-inches Hg vacuum). Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under standard chain of custody procedures. The requirement that a residual vacuum be retained in the canister following sample collection is to ensure that a driving force (pressure) and steady flow rate was maintained until the end of the sampling event.
- The indoor air samples collected via Summa Canister Method should be analyzed for VOCs by the project laboratory using U.S. EPA's TO-14, TO-15 SIM, or TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. As an additional QA/QC measure, the laboratory should perform a duplicate analysis of the sample collected in one of the canisters.

Passive Sampler Method:

There are several passive sampling devices that can be used to sample indoor air. The Radiello® diffusive samplers would be an example of a passive sampler that can be used. The following procedure is based the Radiello® diffusive samplers.

The samplers should be deployed at a height of approximately 5 feet above grade. In addition, one ambient air sample will be placed outside of the building. The ambient air sample should be collected using a 6-litre stainless steel evacuated canister (e.g., Summa® canister) over the selected time period (8-hour or 24-hour). The canister should be obtained certified clean from the laboratory and will be fitted with a laboratory calibrated flow controller to collect the ambient air sample over the selected time period). Sample collection should be terminated so that a residual vacuum can be maintained in the canister. The location of the ambient air sample should be upwind of the prevailing wind direction.

The Standard Operating Procedure (SOP) for sampling using the Radiello® diffusive samplers is presented in **Appendix B (**page A6).

The samples should be transported under standard chain-of-custody procedures to a certified laboratory for analysis. The Radiello® samplers should be analyzed by the project laboratory using EPA's Method TO-17 (EPA, 1999b). The ambient air sample should be analyzed by the project laboratory using EPA's Method TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology. All sample data should be validated.

QA/QC measures implemented during the program for the Radiello® samplers, and as specified in EPA Method TO-17 (EPA, 1999b), include collecting a field duplicate. No additional QA/QC measures will be taken for the ambient air sample.

> Note: The length of time for the ambient air sample using canister will very likely be different than the length of time that the passive sampler will be sampling the indoor air.

19.2.5 Field Instrumentation Calibration

Sampling or monitoring equipment used in the indoor and ambient air sampling program to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specification and requirements. A field calibration of the PID will be completed prior to sampling activities.

Any laboratory-supplied vacuum gauge(s) used to measure canister vacuum should be calibrated by the laboratory. The vacuum gauge should be returned to the laboratory, in order to allow the laboratory to obtain vacuum measurements prior to sample analysis (i.e., checking to ensure canister integrity was maintained during shipment).

The following activities will be performed at the completion of the field work.

1. The equipment should be cleaned and returned to the Equipment Coordinator. All equipment should be cleaned at the site.
2. Monitoring forms and field notes should be sent to the file. The field book should be stored at the appropriate GHD office.
3. Review and compare newly obtained data with historic data and note any unusual or extreme readings.

19.2.6 Data Review and Validation

Following receipt of analytical data, forward data to a GHD chemist for creation of tables, data validation review and reporting, and prepare electronic data deliverable (EDD) as needed. Compare analytical data to applicable indoor air quality standards. If no prescriptive numerical standards are available for your jurisdiction (e.g., New York), consider comparing the data to applicable U.S. EPA indoor air standards (e.g., Residential [10^{-4}] risk values). Note – indoor air concentration data are reported in units of micrograms per cubic meter (µg/m^3) and/or parts per billion by volume (ppbv). Unlike concentration units for groundwater, these units are not directly interchangeable. The molecular weight of the chemical compound is a factor in the conversion from units of mass per unit volume to parts per billion by volume. Ensure the laboratory reports the data in the units required by your guidance (New Jersey, for instance, requires that all data tables and EDD files report data in *only* µg/m^3).

Several states have Rapid Action Levels (RLs), which are more conservative than indoor air screening criteria. Typically, exceedance(s) of the RALs require immediate notifications to stakeholders (e.g., health department, state regulatory agency, property owner, and tenants). Consult your client following data review and prior to making any notifications. Exceedances of RALs often require immediate (e.g., within 2 weeks) mitigation remedies (e.g., SSDS installation, HVAC modification). Consideration should be given to performing an immediate confirmation sampling event.

19.3 References

Cal EPA, 2011. Final Guidance on the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance), Department of Toxic Substances Control, California Environmental Protection Agency, October.

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GHD Field Training Manual

Section 15.0

Soil Gas Sampling Standard Operating Procedures

(T113)

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Please adhere to the following Quality System training requirements:

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Table of Contents

15. Soil Gas Sampling Standard Operating Procedures 1

15.1 Introduction 1

15.2 Prior Planning and Preparation 1

15.3 Safety and Health 2

15.4 Quality Assurance/Quality Control 2

15.5 Design Considerations 3

15.6 Soil Gas and Sub-Slab Probe Installation 4

15.6.1 Installation Procedures - Soil Gas Probes 4
15.6.2 Installation Procedures - Sub-Slab Soil Gas Probes 5
15.6.3 Installation Documentation 8
15.6.4 Follow-Up Activities 9

15.7 Soil Gas and Sub-Slab Sampling Protocol 9

15.7.1 Soil Gas Collection General List of Materials 10
15.7.2 Soil Gas Tracer Compounds 11
15.7.3 Soil Gas and Sub-Slab Probe Leak Testing 12
15.7.4 Sample Collection Procedure 14
15.7.5 Follow-Up Activities 17

15.8 References 17

Figure Index

Figure 15.1 Typical Soil Gas Probe Completion Detail

Figure 15.2 Typical Soil Gas Probe Completion Detail with Prefabricated Screen Implant

Figure 15.3 Typical Small Diameter Sub Slab Soil Gas Probe Completion Detail

Figure 15.4 Rotary Hammer Drilling Hole

Figure 15.5 Finished Hole from Rotary Hammer

Figure 15.6 Assembled Sub-Slab Probe

Figure 15.7 Preparing Assembled Sub-Slab Probe

Figure 15.8 Probe and Outside of the “Outer” Hole

Figure 15.9 Completed Installation of Sub-Slab Probe

Figure 15.10 Completed Installation of Sub-Slab Probe with a Tamper-Resistant Cap

Figure 15.11 Completed Installation of Sub-Slab Probe Plug

Figure 15.12 Typical Large Diameter Sub Slab Soil Gas Probe Completion Detail

Figure 15.13 Vapor Pin™ Assembly with Silicone Sleeve Over the Barbed End

Figure 15.14 Installing the Vapor Pin™

Figure 15.15 Flush-Mount Installation

Figure 15.16 Installed Vapor Pin™ with the Protective Cap

Figure 15.17 Typical Temporary Soil Gas Probe Completion Detail

Figure 15.18 Typical Soil Gas Sampling Assembly Schematic

Forms Index

SP-14 Stratigraphy Log Overburden

SP-15 Well Instrumentation Log

15. Soil Gas Sampling Standard Operating Procedures

15.1 Introduction

The procedures described in this section pertain to the installation of temporary and permanent soil gas and sub-slab probes to assess the vapor intrusion pathway. Soil gas and sub-slab probes are both used to collect soil gas samples; however, soil gas probes are installed at a greater depth, often outside a building, and sub-slab probes are installed to collect soil gas samples from immediately below a slab on grade or a basement floor slab. Permanent probes are recommended when more than one sampling event is required or when assessing seasonal variations in soil gas concentrations. Temporary probes are suitable for conducting a screening level assessment of vapor intrusion where the results could assist in locating future, permanent soil gas probes. Temporary probes are also suitable for conducting a preliminary evaluation of the magnitude and extent of volatile organic compound (VOC) impacts to the subsurface (e.g., such as in the case of a soil gas survey).

15.2 Prior Planning and Preparation

When designing and constructing soil gas and sub-slab probes the following questions should be considered:

1. What is the purpose of the soil gas probes?
2. What are the potential health and safety hazards?
3. What type(s) of soil gas probe construction materials are to be used?
4. What kinds of analyses are required (e.g., VOCs, petroleum hydrocarbon fractions)?
5. What are the geologic/hydrogeologic conditions at the site?
6. What are the seasonally high water table levels?
7. Do perched conditions exist at the site?
8. What is the anticipated total depth of the probes?
9. Are nested soil gas probes required for vertical delineations?
10. Does a vapor barrier already exist under the slab, if so, sub-slab sampling might puncture the barrier, so the hole must be carefully resealed after monitoring is complete?
11. If a basement exists, could the primary entry point(s) for vapor intrusion be through the sidewalls rather than from below the floor slab? If so, sub-slab samples might need to be augmented with samples through the basement walls.
12. Although sample collection and analysis are analogous to those in other types of soil gas sampling, is an analytical method with lower detection limits required since risk-based screening levels for sub-slab samples are lower than those for deeper soil gas samples?

Note: If field staff are not aware of and able to answer all of the above noted questions before undertaking work in the field, the work plan must be reviewed in detail with the Project Coordinator/Manager.

15.3 Safety and Health

GHD is committed to conducting field activities with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP) Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

15.4 Quality Assurance/Quality Control

Quality assurance and quality control procedures should be implemented in every step of the assessment process to ensure the collection of data of acceptable quality. A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate an efficient site investigation.
- Allow for monitoring of staff and subcontractor performance.

- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis.

15.5 Design Considerations

Diameter

Soil Gas Probes

The probe casing diameter should be kept to a minimum to reduce the volume of soil gas that must be purged from the probe during sampling. A maximum casing diameter of 3/4-inch (19 mm) to 1-inch (25 mm) will be used for solid piping casing material (e.g., polyvinyl chloride [PVC]), although casing diameters this large are not recommended for deep soil gas probes (e.g., greater than 15 feet [4.6 m]) since large purge volumes (e.g., milliliters) will result. Casing diameters of 1/4 inch (6.4 mm) to 3/8-inch (9.5 mm) are typical when flexible tubing is used for the casing material (e.g., Teflon® or nylon).

Sub-Slab Probes

A typical sub-slab probe is constructed from small-diameter (e.g., 01/8- or 1/4-inch outside diameter) stainless steel or another inert material and stainless steel compression fittings. The probes are cut at a length to either float in the slab or to extend to the base of the slab.

Screened Interval and Sand Pack Material

Soil Gas Probes

The length and depth of the perforated (screened) section should consider the desired monitoring interval as well as the geologic conditions encountered. A typical screened section would consist of a 6-inch (0.15 m) to 1-foot (0.3 m) perforated section. The use of prefabricated stainless steel screen implants is common. Alternatively, the screened interval can be created from casing material by hand-cutting slots, or hand-drilling holes, into the casing at a regular pattern. For hand-cut or hand-drilled screened intervals, the preferred sand pack material for soil gas probes is pea gravel. For prefabricated screens, the preferred sand pack material is inert 10/20 silica sand (#1 morie sand) or glass beads.

Sub-Slab Probes

A screen is not always used with sub-slab probes. When a screen is utilized, it is often pre-fabricated with a length of approximately 6 inches, due to the limited depth intervals sampled. When a screen is not utilized, the bottom of the probe is left open to facilitate sample collection. The perforated or open section should be consistent with the desired monitoring interval and sub-slab conditions encountered.

Monitoring Parts

For both soil gas and sub-slab probes, airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves should be installed at ground surface to allow for an airtight connection to sampling equipment. The valve is required to isolate the soil gas sampling assembly from the soil gas probe while sampling assembly airtightness tests are conducted prior to probe purging and sampling.

Casing Materials

Soil Gas Probes

The materials selected for soil gas probe casing construction must be compatible with the volatile chemicals anticipated to be present in soil gas. Experience has shown that PVC casing is suitable when VOCs are present. However, as described above, PVC is typically not available in small enough diameters to provide practical soil gas probe purge volumes. To minimize purge volumes, small diameter (e.g., 1/4-inch [6.4 mm] to 3/8-inch [9.5 mm]) flexible tubing (e.g., Teflon® or nylon) is more commonly applied as the soil gas probe casing. Where solid casing is used (i.e., PVC), threaded piping will be used to avoid any possible contamination from solvent cement.

Sub-Slab Probes

The materials selected for sub-slab casing construction must be compatible with the volatile chemicals anticipated to be present in soil gas. Often, 1/4-inch OD stainless steel tubing is utilized to collect sub-slab soil gas. The length of the stainless steel (or brass) tubing is cut to a desired length prior to installation.

15.6 Soil Gas and Sub-Slab Probe Installation

The information contained in this section has been compiled from existing manuals, various reference documents, and a broad range of colleagues with considerable practical and educational backgrounds. This SOP outlines the generic procedures necessary to install a soil gas/sub-slab probe. Site conditions, contaminants and geology may require modification of this procedure. Review applicable government procedures and informational documentation prior to installation.

This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

15.6.1 Installation Procedures - Soil Gas Probes

The soil gas probe is to be installed using Geoprobe® dual tube sampling system to advance a borehole to the target depth. The dual-tube sampling system consists of first advancing a 2 1/2-inch (6.4 cm) diameter inner sampling probe followed by advancing a 3 1/2-inch (8.9 cm) diameter outer casing. The outer casing should cut away disturbed soil immediately surrounding the borehole left by the inner probe. The outer casing should create a zone of reduced soil disturbance due to the inner probe having already been advanced. It is anticipated that using the dual tube system will result in a minimum amount of soil disturbance around the borehole annulus. The soil lithology should be logged during drilling activities and recorded on a field boring log along with any applicable observations. Permanent soil vapor probes can be installed with a conventional drill rig equipped with a hollow-steam auger, although increased formation disturbances would likely result. Rotosonic and mud or air rotary drilling methods are not recommended since they can influence soil vapor sample results and/or alter the physical properties of the subsurface adjacent to the borehole annulus.

The probes should be constructed with a 6-inch (15 cm) to 12-inch (30 cm) long screened interval. The screened interval can be hand-fabricated or prefabricated. The probe casing should be constructed using flexible tubing or solid casing. Flexible tubing (e.g., Teflon® or nylon) of small diameter (e.g., 1/4-inch [6.4 mm] to 3/8-inch [9.5 mm]) is most commonly used in combination with prefabricated screened intervals. Solid casing (e.g., PVC) of small diameter (e.g., 3/4-inch [19 mm] to 1-inch [25 mm]) is most commonly used with hand-fabricated screened intervals. After positioning the screened interval and casing into the borehole, the screen should be surrounded by the appropriate sand pack material (i.e., pea gravel for hand-fabricated screens and 10/20 silica sand for prefabricated screens). When placing the sand pack into the borehole, 1 inch (2.5 cm) of sand pack material should be placed under the bottom of the probe screen to provide a firm footing. The sand pack should extend to 6 inches (15 cm) above the screened interval. A bentonite pellet seal should then be installed to 1-foot (0.3 m) above the sand pack and should be hand-hydrated. The remaining annulus should be backfilled with pre-hydrated bentonite cement. The soil gas probe casing should extend to ground surface and should be fitted with airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves to allow for an airtight connection to soil gas sampling equipment. A flush-mount protective cover should be installed above the soil probe and cemented into place. Schematics of typical soil gas probe installation details are presented on Figures 15.1 and 15.2, respectively, where hand-fabricated and prefabricated screened intervals are applied.

15.6.2 Installation Procedures - Sub-Slab Soil Gas Probes

Sub-slab soil gas probes allow for collection of soil gas samples from directly beneath the slab of a building. Sub-slab soil gas probes are not recommended when groundwater is present directly below the slab, since the slab could allow groundwater to enter the building. Sub-slab soil gas probes can be installed using several different methods: (1) utilizing a small diameter hole, (2) a larger diameter hole w/ flushmount casing and (3) a Vapor Pin™. Summaries of the steps involved are presented below:

Small Diameter Sub-Slab Soil Gas Probe:

A schematic of a typical small diameter sub-slab soil gas probe installation detail is presented on Figure 15.3.

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.
2. Prior to fabrication of the sub-slab vapor probes, use the rotary drill and the two inch diameter drill bit to create a shallow (e.g., 1/4 to 1/2 inch in depth) outer hole that partially penetrates the slab. This outer hole will allow the protective cap to be flush with the concrete surface (Figure 15.4).
3. Use a small portable vacuum cleaner to remove cuttings from the hole.
4. Use the rotary hammer drill and a one-inch drill bit to create a smaller diameter “inner” hole through the remainder of the slab to some depth (e.g., seven to eight centimeters or three inches) into the sub-slab material. Figure 15.5 illustrates the appearance of “inner” and “outer” holes. Drilling into the sub-slab material will create an open cavity, which will prevent the obstruction of any probes during sampling.
5. Use a small portable vacuum cleaner to remove cuttings from the hole.
6. Determine the thickness of the slab and record the measurement.

7. Assemble the vapor point using the basic design of a sub-slab vapor probe illustrated in Figure 15.3.

8. Place the assembled vapor point (Figure 15.6) into the hole and ensure the screen extends beyond the concrete and that the top of the probe is flush with the slab. Also apply the tamper resistant cap so as to not interfere with day-to-day use of the buildings. Cut tubing if necessary (Figure 15.7).

9. Confirm the fit of the rubber shaft plug to the sides of the boring. It should be snug with no gaps present. If additional thickness is necessary, plumbers putty can be added to the sides of the rubber.

10. Mix a quick-drying Portland cement to ensure a tight seal.

11. Inject the Portland cement with a 50 cc syringe or push into the annular space between the probe and outside of the “outer” hole (Figure 15.8).

12. Complete installed vapor point (Figure 15.9) with a tamper-resistant cap (Figure 15.10) or plug (Figure 15.11).

13. Allow cement to cure for at least 24 hours prior to sampling.

Sub-slab probes constructed in the aforementioned manner may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout. Inspect/clean the work area, and return site conditions to their original state.

If the tubing cannot be removed, the tubing should be cemented in place. All surface protective covers must be removed and returned to as close as possible to original site conditions.

Larger Diameter Hole w/ Flushmount Casing:

A schematic of a typical large diameter sub-slab soil gas probe installation detail is presented on Figure 15.12.

1. Prior to drilling holes into the building floor, the location of utilities coming into the building (e.g., gas, electrical, water, and sewer lines, etc.) must be identified. Avoid installing sub-slab soil gas probes near where utilities penetrate the slab as these may be entry points for downward ambient air migration through the slab during soil gas sampling.

2. A concrete corer is used to drill a hole through the concrete floor slab. The diameter of the hole should be sufficient to allow the installation of a protective casing within the hole. A sufficient space for placement of cement is required between the outer edge of the flush-mount casing and the hole in the concrete. Smaller diameter flush-mount protective casings are not recommended as they make accessing the probe within the casing difficult.

3. Once the hole in the concrete is cored and the center core removed, the flush-mount protective casing shroud should be cut to a suitable length. Ideally, the length of the shroud should allow the flush-mount casing to be flush with the surrounding floor while resting on the bedding material beneath the slab.

4. The probe assembly, including a valve at the top of the probe, should be placed so that the tip of the probe is within the bedding material beneath the concrete slab. Care should be taken to not force the probe into the bedding so that the open end of the probe doesn’t plug. Note: the probe assembly should be vacuum-tested on both sides of the valve prior to

installation. A piece of ¼ inch Teflon tubing should be attached at the top of the valve prior to installation. This tubing will allow easier access for the use of compression fittings to attach purging and sampling equipment to the probe.

5. The probe should be cemented into the flush-mount casing with hydraulic cement. The hydraulic cement should form a continuous seal from the bedding material to just below the top hex nut of the probe assembly.

Vapor Pin™

This SOP describes the procedure for installing a sub-slab soil probe using a Vapor Pin™. Borings should be done through the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified by the SOP (see below) and be of sufficient size to penetrate the expected thickness of the concrete present.

General List of Materials

This installation SOP utilizes the following products, which are available from Cox-Colvin & Associates, Inc. Equipment:

1. Silicone sleeve.
2. Hammer drill.
3. 5/8 inch diameter hammer bit (Hilti™ TEYX 5/8” x 22” #00206514 or equivalent).
4. 1½ inch diameter hammer bit (Hilti™ TEYX 1½” x 23” #00293032 or equivalent) for flush mount applications.
5. 3/4 inch diameter bottle brush.
6. Wet/dry vacuum with HEPA filter (optional).
7. Vapor Pin™ installation/extraction tool.
8. Dead blow hammer.
9. Vapor Pin™ flush mount cover, as necessary.
10. Vapor Pin™ protective cap.
11. Equipment needed for abandonment.
12. Vapor Pin™ installation/extraction tool.
13. Dead blow hammer.
14. Volatile organic compound-free hole patching material (hydraulic cement) and putty knife or trowel.

Flushmount Vapor Pin™ Installation Protocol

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.
2. Set up wet/dry vacuum to collect drill cuttings.
3. Drill a 1½ inch diameter hole at least 1¾ inches into the slab.

4. Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.
5. Drill a 5/8 inch diameter hole through the slab and at least six inches into the underlying soil to form a void.
6. Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.
7. Assemble the Vapor Pin™ assembly (Figure 15.13) by threading the Vapor Pin™ into the extraction/installation tool and placing the silicone sleeve over the barbed end.
8. Place the lower end of the Vapor Pin™ assembly into the drilled hole. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin™ to protect the barb fitting and cap, and tap the Vapor Pin™ into place using a dead blow hammer (Figure 15.14). Make sure the extraction/installation tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.
9. Unscrew the threaded coupling from the installation/extraction handle and use the hole in the end of the tool to assist with the installation (Figure 15.15). During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder.
10. Place the protective cap on the Vapor Pin™ (Figure 15.16).
11. Cover the Vapor Pin™ with a flushmount cover.
12. Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil gas conditions to equilibrate prior to sampling.
13. Remove protective cap and connect sample tubing to the barb fitting of the Vapor Pin™.

Temporary Soil Gas Probes

First, a core drill should be used to remove any surface cover, as needed. The temporary soil gas probes should consist of a decontaminated hollow sampling rod driven to the target depth below ground surface. The sampling rod should consist of a decontaminated 1-inch (2.5 cm) hollow stainless steel outer rod that is retracted to expose a 1-foot (0.3 m) long stainless steel screen. The rod should be advanced by a slide hammer to the target depth, and the outer rod retracted to expose the screen at the bottom of the rod. A surface seal comprised of hydrated bentonite cement should be placed around the base of the driven rod. The sampling rod should be completed at ground surface with airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves to allow for an airtight connection to soil gas sampling equipment. A schematic of a typical temporary soil gas probe installation detail is presented on Figure 15.17.

15.6.3 Installation Documentation

Details of each soil gas probe installation should be recorded on GHD's standard Stratigraphic Log Overburden (Form SP-14), or recorded within a standard GHD field book. The Well Instrumentation Log (Form SP-15) is provided for recording the overburden well instrumentation details, and can be used for soil gas probe installations. This figure must note:

- Borehole depth
- Probe perforation intervals
- Filter pack intervals

- Plug intervals
- Grout interval
- Surface cap detail
- Soil gas probe material
- Soil gas probe instrumentation (i.e., riser and screen length)
- Soil gas probe diameter
- Filter pack material
- Backfill material detail
- Stickup/flush-mount detail
- Date installed

The soil stratigraphy encountered at soil gas probes refusal must be recorded in accordance with GHD's standard borehole advancement methods (see Section 5.0).

Each soil gas probe should be accurately located on a site sketch. An accurate field tie to the center of the gas probe from three adjacent permanent features should be completed. The field ties should be located in a different direction from the installation.

Each soil gas probe must be permanently marked to identify the soil gas probe number designation.

15.6.4 Follow-Up Activities

Once the soil gas probe(s) have been completed, the following activities need to be done:

1. Conduct initial monitoring round of gas probes.
2. Submit all logs to the appropriate GHD hydrogeology department, who will be responsible for the generation of the final well log.
3. Survey accurate horizontal and vertical control of the soil gas borings and any pertinent structures needed to create a suitable site map.
4. Prepare an accurate soil gas probe/boring location map. Tabulate soil gas probe construction details.
5. Write-up all field activities including, but not necessarily limited to; drilling method(s), construction material, site geology.
6. Distribute all/any field book(s) to the appropriate GHD office.

15.7 Soil Gas and Sub-Slab Sampling Protocol

The following sampling protocols are for collecting a vapor sample through either a soil gas probe and/or sub-slab probe for the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (USEPA, 1999).

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. Considerations must be given to the types of chemicals of concern, lithology encountered, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

Most soil gas/sub-slab probes are installed at relatively shallow depths (less than ten feet below ground surface) so minimum purge volumes and low-volume samples must be performed to minimize potential breakthrough from the surface or between sampling intervals. Tracer/leak gas is necessary to ensure breakthrough does not occur and that a leak does not occur at any fitting above grade. Sampling should not occur during a significant rain event. A significant rain event is defined as 0.5 inches or greater of rainfall during a 24-hour period by Cal EPA (2012), or 1 centimeter or greater of rainfall during a 24-hour period by MOE (2013). A period of 1 day for coarse-grained soil conditions and several days for fine-grained soil conditions after a significant rain event should occur prior to collecting soil vapor samples. This time interval is required for drainage to occur and soil conditions to return to ambient moisture conditions.

Note: The sampling interval after a significant event should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

Samples from wells with multiple points installed must not be collected simultaneously and approximately 30 minutes must elapse between each sampled interval. Sample times should be documented on the field log. Sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize the potential for vacuum extraction of contaminants from the soil phase. A flow rate greater than 200 mL/min may be used when purging times are excessive, such as for deep wells with larger-diameter tubing. However, a vacuum of 100 inches of water (7.4 inches of mercury [Hg]) or less must be maintained during sampling whenever a higher flow rate is used. Volumes of various tubing sizes are provided in Table 1 in order to aid in calculating purge volumes.

Table 1 Volumes for Select Tubing Sizes

Tubing Size (inches ID)	Volume/ft (liters)
3/16	0.005
¼	0.010
½	0.039

Care must be used during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. Care must also be taken to avoid excessive purging prior to sample collection and prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. The sampling team must avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances) which could potentially cause sample interference in the field.

15.7.1 Soil Gas Collection General List of Materials

The equipment required for soil gas sample collection is as follows:

Flow Meters and Detectors

1. Flow regulator with vacuum gauge. Flow regulators provided by a qualified laboratory are pre-calibrated to a specified flow rate (e.g., 100 ml/min).
2. Photoionization detector (with appropriate lamp).
3. Helium detector (if helium is utilized as a tracer gas).
4. Methane meter for petroleum sites that is capable of also measuring percent of methane (CH4), carbon dioxide (CO2), and oxygen (O2).

Tooling and Supplies

1. Sampling canister (one per location).
2. Regulated flow meter assembly set to a maximum of 200 ml/min (one per location).
3. 1/4 inch tubing (Teflon®, polyethylene, or similar) and assorted fittings.
4. Plastic housing for using tracer gas.
5. 50 ml syringe (for purging).
6. Camera.
7. Adjustable crescent wrenches, small to medium size, and/or open end combo wrenches 9/16 to 1/2 inch.
8. Scissors/snips to cut tubing.
9. Ballpoint pens.
10. Nitrile gloves.
11. Compound to be used as tracer gas - lab grade helium or isopropyl alcohol (IPA).

15.7.2 Soil Gas Tracer Compounds

A leak in the sampling assembly may allow ambient air into the system and dilute the soil gas results (Benton and Shafer, 2007). Therefore, tracer gases must be utilized during the collection of soil gas samples to verify that the sample collected is from the installed sampling point. The presence of a tracer compound, whether liquid or gaseous, can confirm a leak in the sampling train assembly and whether the usability of the sample will need to undergo further evaluation.

Careful thought and consideration must be used when choosing a leak check compound as a tracer, since each compound can have specific benefits and drawbacks.

Helium used as a tracer gas beneath a shroud allows for the screening of the sampling train in the field. In conjunction with the use of a field meter capable of detecting helium, leaks within the sampling train could be detected prior to sampling. A retightening of all fittings prior to collecting the sample for analysis should be done. If a leak has been detected and is unable to be resolved, the sampling point may need to be decommissioned and a new one installed. Only lab-grade helium (UHP-Ultra High Purity) should be used as a tracer, since helium available at general merchandise stores may contain secondary contaminants, such as benzene.

Understanding the relationship between a leak and the concentration detected of the tracer gas used to check for leaks, the potential for absorption of the tracer gas (i.e., helium) onto sample train tubing, and the potential for interference by the tracer gas compound with VOCs is important in answering the data usability. An ambient air leak of up to five percent may be acceptable if quantitative tracer testing is performed. A soil gas vapor well should be decommissioned if the leak cannot be corrected. Any replacement vapor wells should be installed at least five feet from the location where the original vapor well was located

> *Note: The ambient air leak of up to five percent leak should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.*

15.7.3 Soil Gas and Sub-Slab Probe Leak Testing

The use of leak testing is recommended as a quality control check to ensure ambient air has not leaked into the soil gas probe or sampling assembly, which may affect (i.e., dilute) the analytical results. Contaminants in ambient air can also enter the sampling system and be detected in a sample from a non-contaminated sampling probe resulting in a "false positive" result. The leak testing should be conducted as described in the following two steps:

- Step 1 - Vacuum Test: used to ensure that the tubing and fittings/valves that make up the sampling assembly are air-tight
- Step 2 - Tracer Test: used to ensure that ambient air during soil gas sample collection is not drawn down the soil gas probe annulus through an incomplete seal between the formation and the soil gas probe casing.

The vacuum test and tracer test are detailed below.

Step 1 - Vacuum Test

- The sampling assembly must be connected to the soil gas probe valve at the surface casing. Once connected, the sampling assembly will consist of the soil gas probe, the vacuum gauge supplied by the laboratory, personal sampling pump, and Summa™ canister, all connected in series (i.e., in the order of soil gas probe, vacuum gauge, pump, and canister), using tee-connectors or tee-valves.
- The personal sampling pump will be used to conduct the vacuum test. The vacuum test should consist of opening the valve to the personal sampling pump while leaving closed the valves to the Summa™ canister and the soil gas probe. The pump should then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.
- If the pump is capable of drawing flow, or if the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.
- The reading from the vacuum gauge pressure should be recorded in field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly (it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for at least 1 minute.

Step 2 - Tracer Test

A tracer compound is released at ground surface immediately around the soil gas probe surface casing and is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. Two options are described below for the tracer test where either isopropanol (Option A) or helium (Option B) is used as the tracer compound.

Option A - Isopropanol

- For Option A, isopropanol is used as the tracer compound. It is included as an analyte in U.S. EPA's TO-15 method, it is readily available (i.e., as isopropyl rubbing alcohol), and it is safe to use.
- Approximately 1 teaspoon (approximately 4 mL) of isopropanol (rubbing alcohol) should be mixed in 1 gallon of de-ionized water to create an approximate 1/1,000 solution.
- Paper towels soaked in a dilute solution of isopropanol should then be wrapped around the soil gas probe surface casing and ground surface immediately surrounding the surface casing. Soil gas probe surface casing then should be covered over, using clear plastic sheeting that will be sealed to the ground surface. As the ground surface finish permits, sealing the plastic sheeting to ground surface should be accomplished by using tape or by weighting the edges of the plastic sheeting with dry bentonite.
- Immediately before conducting the soil gas probe purging, remove the paper towels from the solution, wringing out the towels so they are very damp, but not dripping. Place them around the vapor probe and seal them in place using the plastic sheeting.
- The isopropanol solution should be kept fresh, with new solution being made every hour. The solution should be mixed at a central location away from the sampling activities. The isopropanol should be kept tightly capped and kept away from all sampling equipment. The solution should be kept away from the sampling assembly until immediately before sample collection begins. Sampling personnel must wear latex gloves while handling the solution and soaked paper towels, and will remove the gloves while working with the sampling assembly.
- Soil samples with laboratory analytical results for isopropanol that are greater than 10 percent of the starting concentration of isopropanol in the vapors emitted from dilute isopropanol solution should not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007). The starting concentration should be calculated based on the concentration of isopropanol in the dilute solution, the vapor pressure of isopropanol, and Henry's law.
- A disadvantage in using isopropanol as the tracer compound is that it will not be known whether a significant leak occurred until after the cost of analyzing the sample has been spent. Elevated levels of isopropanol can also interfere with laboratory analytical method detection limits.

Option B - Helium

- The presence of helium within the sampling assembly should be monitored during purging and soil gas sample collection using a helium meter installed in-line with the sampling assembly. The meter should be positioned along the sampling line just before the personal sampling pump.
- Helium is readily available at a variety of retail businesses, is safe to use, and does not interfere with laboratory analytical method detection limits.

- A containment unit is constructed to cover the soil gas probe surface casing. The containment unit should consist of an overturned plastic pail set into a ring of dry bentonite to create a seal between the ground surface and the rim of the pail. The pail can be set directly on top of the sampling assembly tubing connected to the soil gas probe, which when pressed into the dry bentonite, should create a sufficient seal around the tubing. The pail will have two holes: one to allow for the introduction of helium; and the other to allow for air trapped inside the pail to escape while introducing the helium. The second hole will also allow insertion of the helium meter to measure the helium content within the pail.
- Prior to soil gas probe purging, helium will be introduced into the containment unit to obtain a minimum 50 percent helium content level. The helium content within the containment unit should be confirmed using the helium meter and recorded in the field logbook. Helium should continue to be introduced to the containment unit during soil gas probe purging and sampling and care should be taken not to increase the pressure within the containment unit beyond that of atmospheric pressure.
- During soil gas probe purging and sampling, the helium meter should be connected in-line with the sampling assembly. In the event that the helium meter measures a helium content with the sampling assembly of greater than 10 percent of the source concentration (i.e., 10 percent of the helium content measured within the containment unit), the soil gas probe will be judged to permit significant leakage such that the collected soil gas sample will not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007).
- An advantage of using helium as the tracer compound is that a significant leak can be detected in the field and the cost of analyzing the Summa™ canister can be avoided.

Note: The 10 percent of the source concentration should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

15.7.4 Sample Collection Procedure

1. Soil gas samples for assessing the vapor intrusion pathway must be collected using an acceptable canister, including certified clean Summa™ canisters. Only canisters certified clean at the 100 percent level can be used for soil gas sampling activities (i.e., pre-cleaned at the laboratory in accordance with U.S. EPA's TO-15 method and documentation of the cleaning activities will be provided by the laboratory). Summa™ canisters typically come in 1-, 1.7-, and 6-liter capacities, depending upon laboratory availability.
2. The canisters must be fitted with a laboratory-calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum soil gas sampling flow rate recommended by Cal EPA (2012) of 100 to 200 mL/min. The 100 mL/min maximum flow rate is equivalent to sample collection times of 10, 17, or 60 minutes, respectively, for of 1, 1.7, or 6 liter canister capacities. A maximum flow rate of 100 mL/min is recommended to limit VOC stripping from soil, prevent the short-circuiting of ambient air from ground surface down the soil gas probe annulus that would dilute the soil gas sample. A maximum flow rate of 100 mL/min increases confidence that the soil gas sample is drawn from immediately surrounding the screened interval.
3. A vacuum gauge should be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual

canister vacuum at the end of sample collection. The vacuum gauge will be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory.

4. The canister should be connected to the soil gas probe valve at the surface casing using the sampling assembly (see Figure 15.18). The sampling assembly is connected using short lengths (e.g., 1-foot [0.3 m]) 1/4-inch (6.4 mm) or 3/8-inch (9.5 mm) diameter tubing (the tubing material will be Teflon® or nylon) and airtight stainless steel or brass tee-connectors and tee-valves (e.g., Swagelok® type). The canister should be connected to the soil gas probe along with a vacuum gauge and a personal sampling pump, all in series, using tee-connectors or tee-valves (in the order of soil gas probe, vacuum gauge, pump, and canister). A tee-valve should be used to connect the pump, which will allow the pump to be isolated from the sampling assembly during sample collection. Fresh tubing must be used for each sample.

5. Prior to collecting a soil gas sample, the stagnant air in the sampling assembly tubes and soil gas probe casing/sand pack must be removed. The soil gas probes should be purged prior to sampling using the personal sampling pump at a flow rate of less than 200 mL/min. A flow rate greater than 200 mL/min may be used when purging times are excessive, such as for deep wells with larger-diameter tubing. However, a vacuum of 100 inches of water (7.4 inches of Hg) or less must be maintained during sampling whenever a higher flow rate is used. This ensures that the collected soil gas sample is representative of actual soil gas concentrations within the formation. Measurements of the lengths and inner diameters of the above-ground sampling assembly and below-ground gas probe casing, screen, and sand pack should be used to calculate the "purge volume" (the purge volume will consider the pore volume of the sand pack assuming a 30 percent sand pack porosity). Prior to sample collection, two to three purge volumes should be drawn from the probe/sample assembly, unless otherwise required by the applicable regulatory guidance. The purge data (calculated purge volume, purging rate, and duration of purging) should be recorded in the field logbook.

6. Prior to purging, a vacuum, or tightness, test should be conducted on the sampling assembly as the first of two leak-testing steps, as described further in Section 15.7.3. Briefly, this first leak-testing step (the vacuum test) should consist of opening the valve to the personal sampling pump leaving the valves to the Summa™ canister and the soil gas probe closed. The pump should then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are airtight. Further details of the vacuum test are described in Section 15.7.3.

7. Prior to purging, and following the vacuum test, the set-up for the second of the two leak-testing steps should be conducted. The second leak-testing step is the tracer compound step. A tracer compound is released at ground surface immediately around the soil gas probe surface casing. The tracer test is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. The tracer compound is either monitored using a meter connected in-line to the sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the soil gas samples (e.g., isopropanol). The setup requirements of the tracer compound leak-testing step are described in Section 15.7.3.

8. Following the vacuum test, and the setup for the tracer compound leak-testing step, the soil gas probe purging should commence by opening the valve to the soil gas probe and activating the personal sampling pump (and leaving closed the valve to the Summa™

canister). At the start and the end of the purging period, the total concentration of volatile organic vapors of the personnel sampling pump exhaust gas should be monitored using a portable photoionization detector (PID) meter. The PID meter should be connected in series after the personal sampling pump. Since typical PID instrument flow rates vary from approximately 300 to 500 mL/min (depending on the manufacturer and model), drawing a sample into the PID meter through the personal sampling pump will likely increase the purging flow rate temporarily, until a reading from the PID meter is obtained. PID readings should be recorded and entered in the field logbook and chain of custody form. The PID readings should provide the laboratory with an indication of whether a sample could require dilution before analysis.

9. Following purging, the valve to the personal sampling pump should be closed, and the valves to the soil gas probe and Summa™ canister opened to draw the soil gas sample into the canister. This should be completed concurrent with continued application of the leak-testing tracer compound. The vacuum gauge reading must be recorded during sample collection. Should the vacuum gauge reading remain elevated above 10 inches Hg for more than 30 minutes, this will be taken to indicate that the initial vacuum in the canister has not sufficiently dissipated, and that the soil screened by the soil gas probe does not produce sufficient soil gas to permit sample collection due to low permeability soil. If low permeability conditions are encountered, the probe can be sampled using the techniques outlined in Appendix D (Soil Gas Sampling in Low Permeability Soil) of Cal EPA (2012).

10. To ensure some residual vacuum in each canister following sample collection, the canister vacuum should be recorded at approximately 80 percent through the expected sample collection duration. With a 100 mL/min maximum flow rate, the expected sample collection duration would be 10, 17, or 60 minutes, respectively, for canister capacities of 1, 1.7, or 6 liters. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until vacuum reading is below this threshold, unless the vacuum remains above 10-inches Hg for more than 30 minutes, as described above. A minimum 0.5 to 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap must be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under chain-of-custody procedures.

Note: The 0.5 to 1-inch Hg residual vacuum should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

11. The vacuum gauge provided by laboratory must be returned with the canister samples to check residual vacuum in the laboratory prior to sample analysis and recorded on the analytical data report. This check will ensure sample integrity prior to laboratory analysis, and that the canister has not become compromised during shipment to the laboratory.

12. If the critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves are to be re-used during sampling, they must be cleaned in accordance with laboratory requirements by purging with zero air (provided by laboratory) for minimum 45 seconds at minimum 75 psi (153 inches of Hg).

13. The canisters should be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook should be maintained to record all soil gas sampling data.

14. The canisters should be listed on the chain-of-custody in order of suspected highest to lowest impact, as evidenced by the recorded PID readings. Indicate on the chain-of-custody for the laboratory to analyze the canisters in order from the lowest to highest PID reading.

The soil gas samples should be analyzed for VOCs by the project laboratory using U.S. EPA's TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. QA/QC measures implemented during the soil gas sampling event will include the two-step leak testing procedure (see Section 15.7.3), maintaining a minimum residual vacuum in the Summa™ canisters following sample collection, collection of one duplicate per sampling event or from at least 10 percent of the samples obtained, and collection of an ambient air sample (if needed). As an additional QA/QC measure, the laboratory should conduct a duplicate analysis of the sample collected in one of the canisters.

15.7.5 Follow-Up Activities

The following activities should be performed at the completion of the field work.

1. Review and compare newly obtained data with historic data and flag unusual or extreme readings for review.
2. Soil gas concentrations are reported in units of µg/m^3 or ppbv. Unlike concentration units for groundwater, these units are not directly interchangeable. The molecular weight of the compound in question is a factor in the conversion from units of mass per unit volume to parts per billion by volume.
3. Ensure site access keys are returned.
4. The equipment should be cleaned and returned to the Equipment Coordinator. All equipment should be cleaned at the site.
5. Monitoring forms and field notes should be sent to the file. The field book should be stored at the appropriate GHD office.

15.8 References

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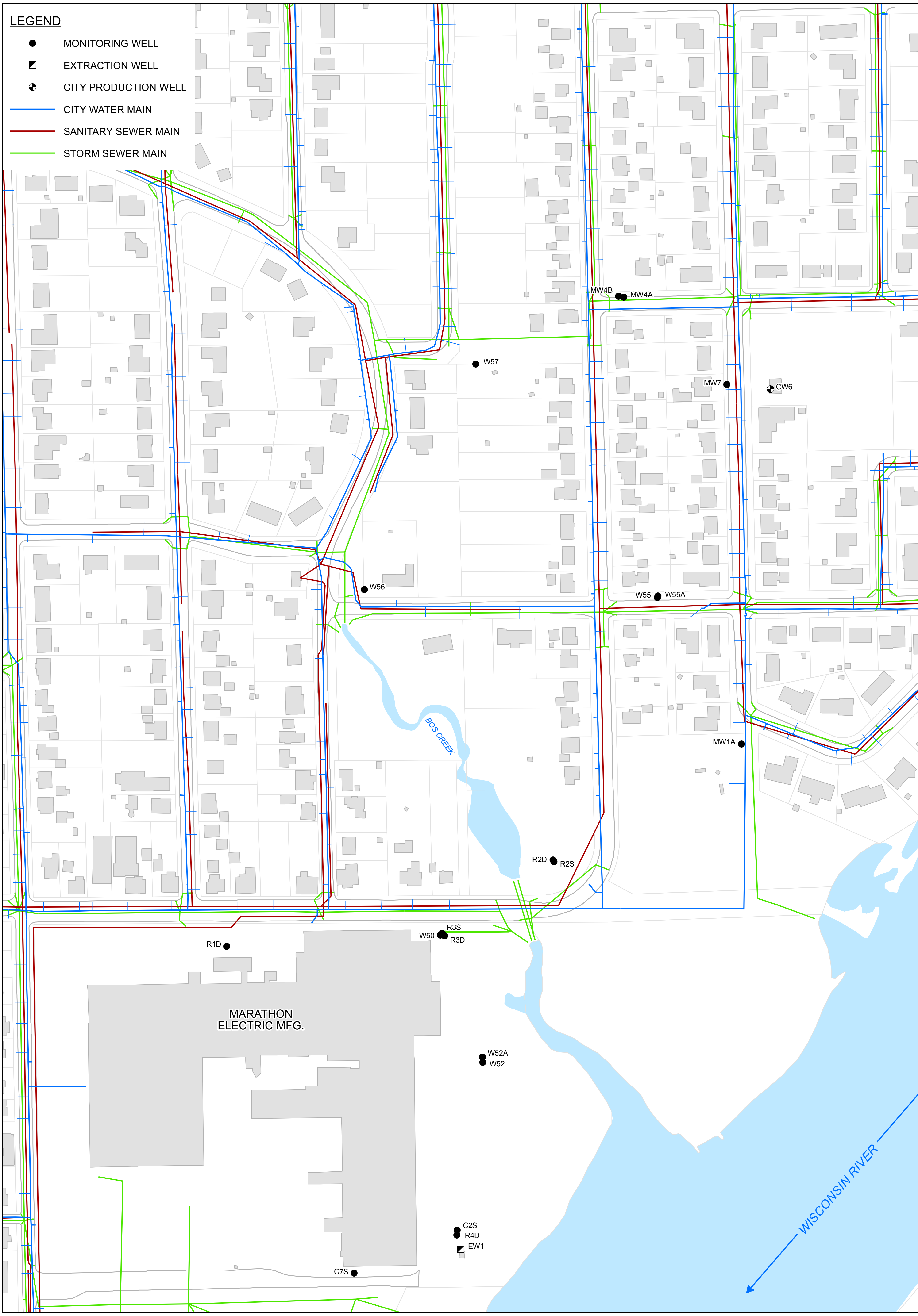
Appendix D

Sewer and Water Utility Maps



Source: Marathon County

0 100 200 ft

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN
VAPOR INTRUSION EVALUATION WORK PLAN

003978-00
Feb 17, 2017

WEST BANK UTILITIES

APPENDIX D

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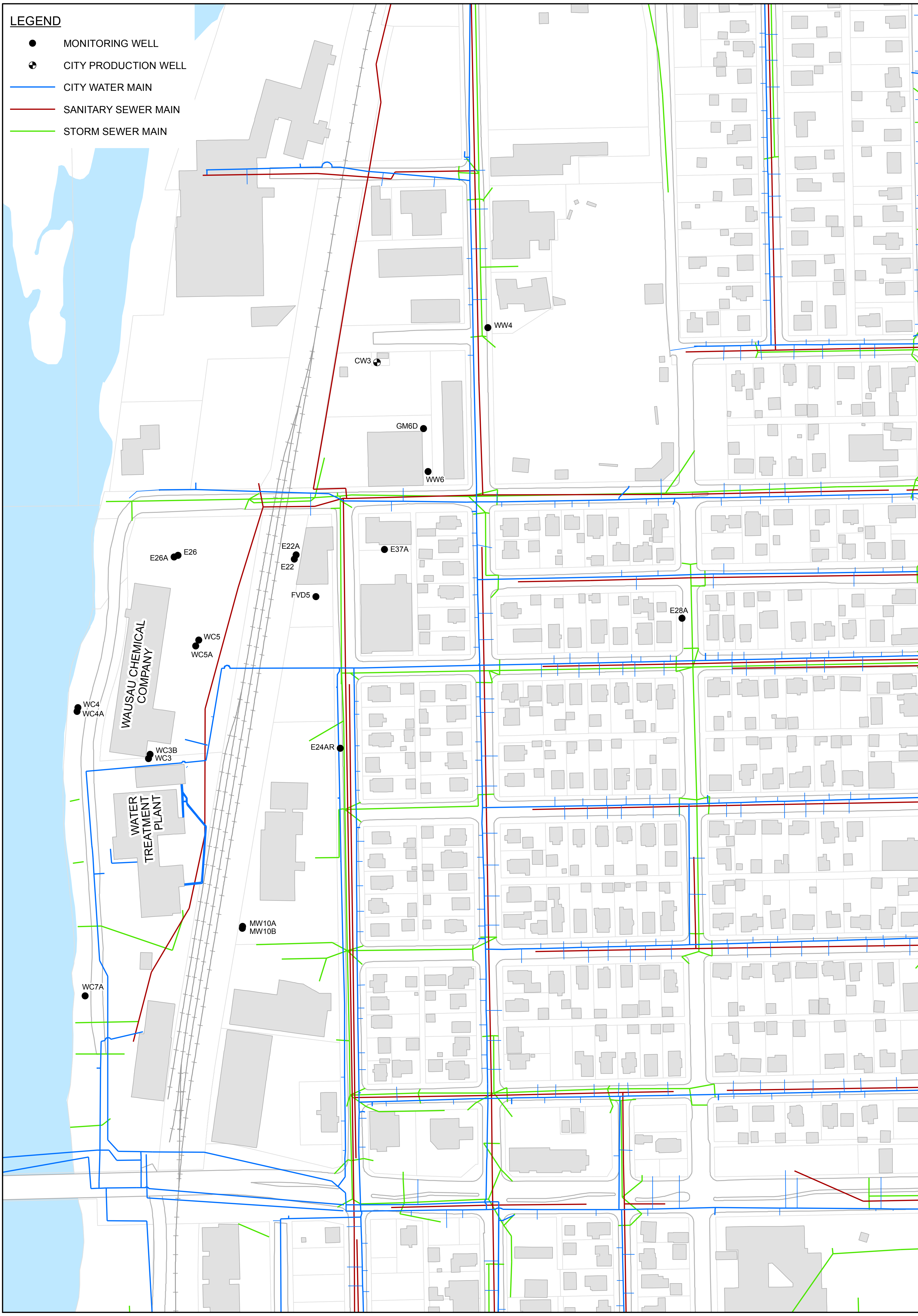

Source: Marathon County

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN
VAPOR INTRUSION EVALUATION WORK PLAN

003978-00
Feb 17, 2017

EAST BANK UTILITIES

APPENDIX D

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Appendix E

2023 Addendum: Vapor Intrusion Evaluation Work

2023 Addendum: Vapor Intrusion Evaluation Work Plan

Wausau Water Supply NPL Site
Wausau, Wisconsin

City of Wausau

January 31, 2023

→ **The Power of Commitment**

Project name	Lonsdorf-Wausau Superfund RD/RA						
Document title	2023 Addendum: Vapor Intrusion Evaluation Work Plan | Wausau Water Supply NPL Site						
Project number	003978						
File name	003978-RPT-49-2023 Adddendum						
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
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The Power of Commitment

Contents

1.	**Introduction and Background**	**1**
1.1	Site Background	1
1.2	Land Use Near Site	2
1.3	Site Contaminants of Potential Concern	2
2.	**VI Investigation Work Plan**	**2**
2.1	Overview	2
2.2	Building Assessments and Access Agreements for Sub-slab Vapor Sampling	3
3.	**Field Investigation Procedures**	**3**
3.1	Overview	3
3.2	Sub-Slab Vapor Pin Installation and Sampling	3
3.2.1	Vapor Pin Installation	3
3.2.2	Sub-slab Vapor Sampling Setup and Testing Procedures	4
3.2.3	Sub-slab Sample Collection Procedure	4
3.3	Indoor Air Sampling	5
4.	**VI Preferential Pathway Investigation**	**6**
4.1	Manhole Vapor Sampling	6
5.	**Reporting**	**6**
6.	**Schedule**	**7**

Table index

Table 1.1 Contaminants of Potential Concern Physical Properties

Figure index

Figure 1.1 Site Location
Figure 1.2 Site Plan
Figure 1.3 Land Use Areas
Figure 3.1 Proposed Sub-slab Sampling Locations
Figure 3.2 Preferential Pathway Investigation Sampling Locations

Appendices

Appendix A	GHD Vapor Intrusion Evaluation Summary Report 2019
Appendix B	Quality Assurance Objectives
Appendix C	Property Owner Introduction Letter Example and Access Agreement Letter Example
Appendix D	Field Protocols and Field Sampling SOPs
Appendix E	Sewer and Water Utility Maps

1. Introduction and Background

In response to the U.S. Environmental Protection Agency's (EPA) letter of January 19, 2023, this Vapor Intrusion Evaluation Work Plan Addendum provides the proposed scope of work and field procedures for vapor intrusion (VI) evaluation and investigation at the Wausau Water Supply Superfund Site in Wausau, Wisconsin (Site). This Work Plan has been prepared in accordance with the EPA guidance document: *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air (June, 2015), Wisconsin Department of Natural Resources (WDNR) guidance document Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin (January 2018) and WNDR Guidance for Documenting the Investigation of Human-made Preferential Pathways Including Utility Corridors (June 2021).*

This Work Plan Addendum (Work Plan) aims to collect additional subsurface vapor data to determine the potential for vapor intrusion to indoor air. Specific tasks to be conducted include:

– Installation of sub-slab vapor sampling points
– Sampling and analysis of sub-slab soil vapor and indoor air

Data obtained from this proposed sampling event will be used in conjunction with existing data to fill in data gaps and update the Conceptual Site Model (CSM).

1.1 Site Background

The Wausau Superfund Site is located on the north side of the City of Wausau, in north-central Wisconsin, along the Wisconsin River in Marathon County. Figure 1.1 shows the location of the Site. The Site consists of two contaminant source areas separated by the Wisconsin River. The East Bank portion of the Site is related to solvent spills on property operated by Wausau Chemical Corporation (WCC). The West Bank portion of the Site is related to the former City of Wausau landfill. The former landfill property is presently owned by Regal Beloit Corporation (formerly Marathon Electric Company). These two properties are considered source areas for contaminants in the aquifer, which is the source of drinking water for the City of Wausau. The East Bank and West Bank areas are depicted on the Site Plan, Figure 1.2.

Groundwater and soil remediation has been ongoing at the two source areas since approximately 1985. Remedial actions by the Group were initiated in the early 1990s in accordance with September 29, 1990, Record of Decision (ROD) and the Consent Decree (CD) entered with the court on January 24, 1991. Remedies implemented at the Site consisted of two soil vapor extraction (SVE) systems to address the source areas and groundwater extraction and treatment, utilizing existing municipal production wells (CW3 and CW6) and a remediation well (EW1).

Source area remediation was accomplished by installing SVE systems at Marathon Electric (West Bank) and Wausau Chemical (East Bank) in January 1994. The SVE system at Marathon Electric operated until April 1996, when the West Bank source remediation was approved as complete. The East Bank SVE system was modified in 1996 and continued to operate until January 2001. The East Bank source remediation was approved as complete in 2007.

Groundwater remediation was provided through two existing municipal production wells (CW3 and CW6) and one extraction well installed at Marathon Electric (EW1). Air strippers located at the Wausau water treatment plant treat water from the municipal supply wells. Water from EW1 was treated by air stripping (over riprap on the riverbank) before being discharged to the Wisconsin River.

EW1 stopped operating in July 2012 due to pump failure. Since EW1 has essentially completed its performance goal, the Group proposed a pilot study to confirm that City wells CW6 and CW3 effectively contain the contaminant plume without pumping at EW1. The EW1 Shutdown, Pilot Study Report, was submitted to EPA in March 2015.

Additional groundwater remediation was provided by a groundwater extraction system operated by WCC between 1985 and 1996 as an interim remediation measure. The extraction system at WCC consisted of a series of shallow wells at the south end of the WCC property. Groundwater from this system was treated by air stripping. This system was in addition to the requirements of the ROD or the CD and operation ceased in 1996.

From March 2017 to April 2019 GHD performed additional field work to supplement existing Site data to better understand the potential for vapor intrusion (VI) risk in areas adjacent to the known groundwater plume footprints at the Site. The VI Evaluation Summary Report is provided in Appendix A.

1.2 Land Use Near Site

Land use is depicted in Figure 1.3. This map shows residential, commercial/industrial, railroad, and City properties.

1.3 Site Contaminants of Potential Concern

Site contaminants of potential concern (COPC) are limited to the following chlorinated VOCs:

East Bank

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- cis-1,2-Dichloroethylene (c12DCE)
- Vinyl chloride

West Bank

- Trichloroethylene
- cis-1,2-Dichloroethylene
- Carbon tetrachloride (CT)
- Chloroform

The physical properties of these VOCs are summarized in Table 1.1. Significant concentrations of CT and chloroform were detected in only one well, C3S, which is a shallow well in the former City landfill. These compounds were not detected from Marathon Electric property and are limited to the landfill.

The East Bank COPCs are related to a release of PCE, which has degraded over time to TCE, c12DCE, and low concentrations of vinyl chloride.

2. VI Investigation Work Plan

2.1 Overview

This work plan presents the procedures for additional investigations and evaluations to help complete the conceptual site model relative to VI. Existing groundwater data do not suggest an immediate VI risk to residential or commercial/industrial properties. Proposed fieldwork includes:

1. Re-install vapor pins at the select locations noted below.
2. Collect sub-slab vapor samples at select commercial/industrial locations (Rexnord north and south buildings, Dental Clinic, and Music Shop) on the East and West Bank. These locations will be placed near or at the same location as the past sampling events.

3. Collect vapor samples from the sanitary sewer manholes that are "up-flow" and "down-flow" of the Former Wausau Chemical Company as part of the preferential pathway investigation.

The additional requested VI investigation activities will provide additional lines of evidence to better determine potential VI risks.

The elements of the field investigations are presented below. Field procedures are detailed in Section 3 and quality assurance (QA) objectives are presented in Appendix B.

2.2 Building Assessments and Access Agreements for Sub-slab Vapor Sampling

Additional sub-slab vapor sampling is proposed for commercial buildings, as noted above. Upon implementing this work plan addendum, letters will be sent to the businesses potentially affected by field sampling activities. This letter will provide an introduction/reminder to explain the purpose of the proposed fieldwork and describe where the locations where sub-slab sampling is proposed as part of the investigation, a combination introduction/access agreement letter will be sent to the affected property owners. An example combination letter is also presented in Appendix C.

Sub-slab sampling will be assessed to obtain information that can be used to help interpret results and better assess potential VI risk. Information to be obtained by these assessments includes the following:

1. Basement depth or crawlspace; the presence of a sump
2. Basement floor type; concrete, soil, other
3. Locations of normally occupied areas
4. Type of ventilation; air exchange rates
5. Radon mitigation, vapor barrier
6. Chemical usage

3. Field Investigation Procedures

3.1 Overview

The following sections describe the installation of sampling devices and sampling procedures for each media to be evaluated during VI investigation activities. Proposed investigation locations are presented on Figures 3.1.

3.2 Sub-Slab Vapor Pin Installation and Sampling

3.2.1 Vapor Pin Installation

With the property owner's permission, one or more sub-slab vapor pins will be installed in the basement or floor slab of the subject property. The number of potential pins will depend on the size of the floor area and layout of the building. One to three sub-slab vapor pins will be installed per building at locations agreed upon by GHD and the building owner/manager. The following describes the procedures for the installation of sub-slab pins.

1. Prior to drilling holes in a foundation or slab, utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines) will be located. The sample location will be cleared using knowledgeable site personal or a private utility locate company.

2. Prior to installation of the sub-slab Vapor Pin™, a rotary hammer drill will be used to drill a 1.5 inch diameter outer hole to a depth of approximately 1 inch below the surface that partially penetrates the slab. This outer hole will allow the protective cap to be flush with the concrete surface.
3. A small portable vacuum cleaner will be used to remove cuttings from the hole.
4. A rotary hammer drill with a 5/8-inch bit will be used to drill an inner hole through the remainder of the slab to a depth of 4 inches below the slab. Drilling into the sub-slab material will create an open cavity, which will prevent the obstruction of any pins during sampling.
5. A 3/4–inch diameter bottle brush and a small portable vacuum cleaner will be used to remove cuttings from the hole.
6. The thickness of the slab will be measured and recorded.
7. A Vapor Pin™ assembly will be driven into the 5/8-inch hole. The Vapor Pin™ creates an airtight seal without the need for cement.
8. The Vapor Pin™ will be capped to prevent air exchange between the subsurface and indoor air and a flush-mount cap will be placed at the concrete surface so as to not interfere with day-to-day use of the building.

Sub-slab pins constructed in the aforementioned manner can be abandoned by removing any tubing and all surface protective covers. The Vapor Pin™ can be removed using a tool provided with the installation kit. The hole can then be backfilled with cement grout.

3.2.2 Sub-slab Vapor Sampling Setup and Testing Procedures

The sub-slab sampling assembly will be connected to the Vapor Pin™. Once connected, the sampling assembly will consist of the soil gas pin, Teflon tubing, vacuum gauge supplied by the laboratory, personal sampling pump, and vacuum canister, all connected in series (i.e., in the order of soil gas pin, vacuum gauge, pump, and canister), using T-connectors or T-valves.

A personal sampling pump, or similar, will be used to conduct a vacuum test. The SOP for vacuum testing is presented in Appendix D.

If the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.

3.2.3 Sub-slab Sample Collection Procedure

1. Sub-slab vapor samples will be collected using the water dam method to prevent potential air leaks during sampling. The SOP for the water dam method is presented in Appendix D.
2. Sub-slab vapor samples will be collected using batch certified clean vacuum canisters. Only canisters certified clean at the 100 percent level will be used for soil gas sampling activities Vacuum canisters will have a capacity of 1-liter or 6-liters depending on laboratory requirements and availability.
3. The canisters will be fitted with a laboratory-calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min). The 100 mL/min maximum flow rate is equivalent to a sample collection time of 60 minutes for a 6-liter canister.
4. A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection.
5. The canister will be connected to the soil vapor pin using a sampling assembly comprised of short lengths of ¼-inch Teflon or Teflon lined tubing and polypropylene valves and fittings. The canister will be connected to the soil vapor pin along with the vacuum gauge and a purge pump (for soil vapor pin purging), in series. A T-valve will be used to connect the purge pump, which allows the pump to be isolated from the sampling assembly during sample collection. New tubing will be used for each sample.

6. Prior to collecting a soil gas sample, the stagnant air in the sampling assembly tubes and soil gas pin will be removed. The soil gas pins will be purged prior to sampling using a sampling pump at a flow rate of not more than 200 mL/min. Prior to sample collection, three purge volumes will be drawn from the pin/sample assembly.
7. At the start and the end of the purging period, the total concentration of volatile organic vapors of the pump exhaust gas should be monitored using a (PID). The PID will be connected in series after the personal sampling pump. PID readings will be recorded and entered in the field logbook. If VOCs are detected by the PID, the laboratory will be advised whether a sample could require dilution before analysis.
8. Following purging, the valve to the purge pump will be closed, and the valves to the soil gas pin and vacuum canister opened to draw the soil gas sample into the canister. This should be completed concurrent with continued application of the leak-testing water dam.
9. To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded after approximately 8 minutes of the expected 10 minute sample collection duration. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until the vacuum reading is below this threshold. A minimum 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap must be securely tightened on the inlet of the vacuum canister prior to shipment to the laboratory under chain-of-custody procedures.
10. The critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves will not be re-used during sampling.
11. The vacuum canister samples will be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all soil gas sampling data.

East Bank vapor samples will be analyzed for PCE, TCE, c12DCE, and vinyl chloride. West Bank samples will be analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

The indoor air samples will only be analyzed if the corresponding sub-slab samples show any exceedances.

Sub-slab vapor sampling QA objectives for the TO-15 analytical method are provided in Appendix B. Field procedures are presented in Appendix D.

3.3 Indoor Air Sampling

Sub-slab and indoor air sampling are being proposed for commercial/industrial buildings. Indoor air samples will be collected concurrently with sub-slab samples in accordance with WDNR guidance. A summary of the steps involved in the indoor air sampling is presented below:

1. Similar to the soil gas samples, the indoor air samples will be collected using laboratory-certified pre-cleaned 6-liter stainless steel vacuum canisters. Canisters will be certified as pre-cleaned at the 100 percent level in accordance with EPA Method TO-15.
2. Sample canisters will be fitted with laboratory-calibrated critical orifice flow regulators sized to restrict the maximum air sample collection flow rate into the canister and provide a sample collection duration of approximately 24 hours.
3. The laboratory will supply a vacuum gauge for each canister and will be used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection.
4. The canisters will be deployed at a typical breathing zone height of approximately 4 to 5 ft. above the floor/ground surface.
5. Collection of field duplicate indoor air samples will be achieved by deploying two canisters side by side simultaneously with a single inlet and a T-connection. Field duplicate samples will be collected at a frequency of 1 in 20 indoor air and outdoor ambient air samples per sampling event.

6. Indoor air sampling will be continued until the vacuum reading is between -10 and -5 in Hg. The vacuum gauge reading must not be greater than -1 in Hg for the sample to be considered valid. After recording the final canister vacuum reading, the canister valve will be closed and the safety cap securely tightened on the inlet of the canister. Sample canisters will be shipped to the laboratory under chain-of-custody procedures.
7. The canister serial numbers will be recorded and a unique sample identification number will be assigned to each canister/sample identifying the sample number, date, time, and sampler's initials. A bound field logbook will be maintained to record all indoor air/outdoor ambient air sampling field measurements.

East Bank indoor air and ambient air samples will be analyzed for PCE, TCE, c12DCE, and vinyl chloride. West Bank indoor and ambient air samples will be analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

Indoor air sampling QA objectives TO-15 analytical method are provided in Appendix B. Field procedures are presented in Appendix D.

4. VI Preferential Pathway Investigation

The historical groundwater and VI analytical results do not indicate that any contaminated utility conduits exist, nor are they contributing to commercial or residential buildings. The City of Wausau provided utility maps showing the locations of sewer and water mains in the investigation areas. After reviewing these maps in relation to our investigation areas, there appear to be no direct connections to the commercial/industrial buildings.

In addition, considering that utility backfill is typically compacted fill, the native soils may be more permeable than backfilled utility trenches, and preferential pathways are not likely to occur. As mentioned above, the City of Wausau provided utility maps showing the locations of sewer and water mains in the investigation areas. Copies of these maps are provided in Appendix E.

However, to confirm our findings above, we propose collecting three VI samples as required in the WNDR Guidance Document. The samples will be collected from sanitary sewer manholes that are "up-flow" and "down-flow" of the Former Wausau Chemical Company, as shown in Figure 3.2.

4.1 Manhole Vapor Sampling

Per the WDNR Guidance Document, the recommended sampling method for manholes currently consists of collection of a grab sample with an evacuated canister. As long as the opening to the manhole is small, there is no need to seal the tubing. If the manhole cover must be completely removed, allow the air in the sewer to equilibrate for an hour after the cover is replaced before a sample is collected. It is appropriate to collect a grab sample (that is, without a flow controller). A one-liter evacuated canister will be sufficient in most circumstances.

The tubing will be placed down the manhole to a depth that is approximately 1 foot above the bottom of the sewer or top of liquid.

Since sanitary sewers are not a concern for allowing vapor phase contaminants into occupied structures, these vapor samples will be analyzed for PCE, TCE, c12DCE, and vinyl chloride, similar to the other samples collected on the East Bank.

5. Reporting

Laboratory results will be provided as GHD receives them from the lab. After completing the scope of work described herein, a field investigation report will be prepared for submittal to WDNR and EPA. The report will include a narrative of the field investigation activities, tabulated data, figures, data interpretation, laboratory reports, and recommendations. A final report will be prepared for review by WDNR and EPA.

6. Schedule

It is anticipated that the field investigation described herein will take approximately two to four days to complete, although property access issues could potentially delay portions of the investigation.

Upon completion of the supplemental VI evaluation, a final report will be submitted to WDNR and EPA within 90 days after receipt of the final laboratory report.

Table

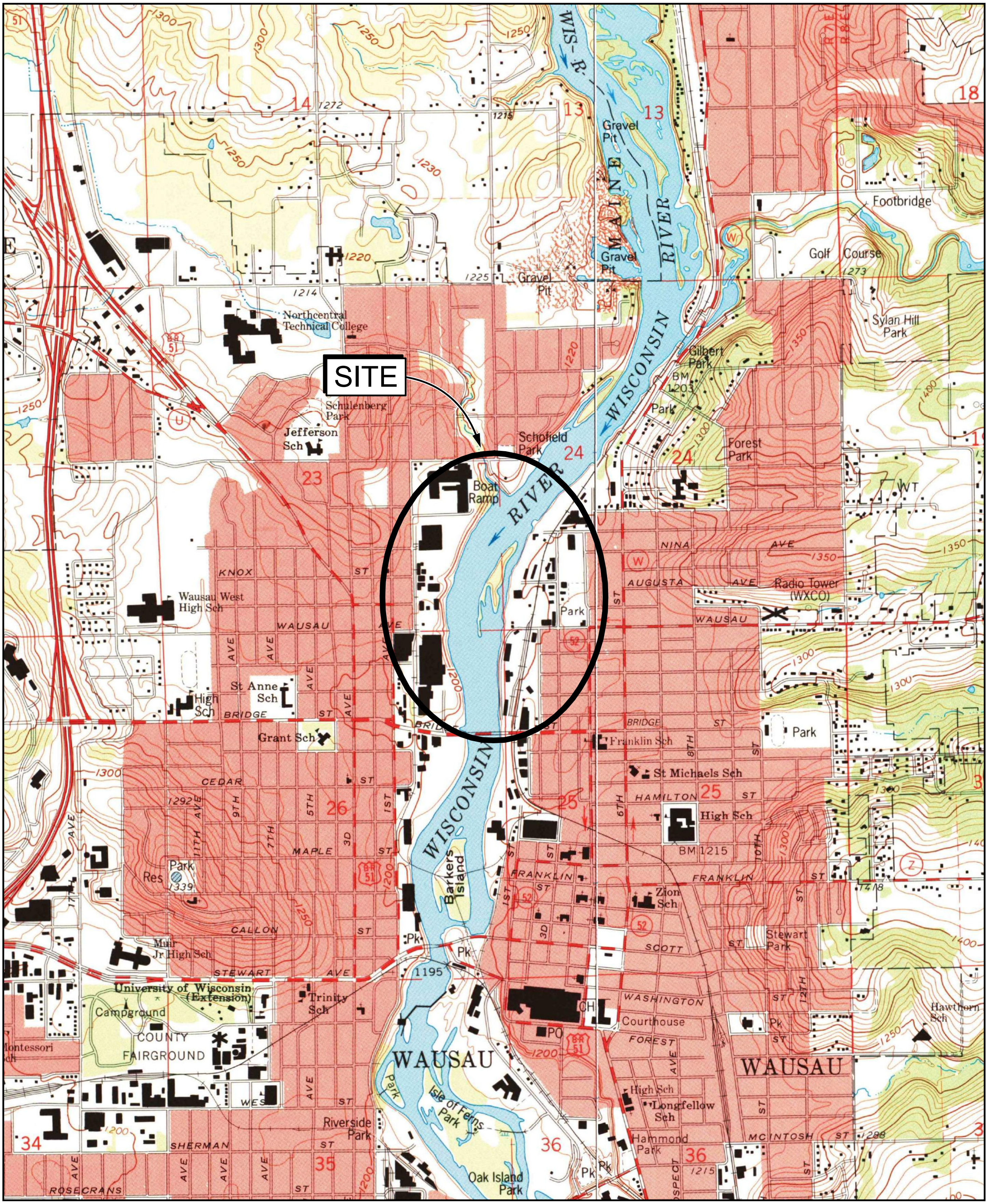
Table 1.1

Contaminants of Potential Concern Physical Properties
Vapor Intrusion Work Plan Addendum
Wausau Water Supply Superfund Site
Wausau, Wisconsin

Chemical	CAS No.	Molecular Weight (g/mole)	Henry's Law Constant (unitless)	Vapor Pressure (mm Hg)	Density (g/cm^3)	Diffusivity in Air (cm^2/sec)	Diffusivity in Water (cm^2/sec)	Soil Partition Coefficient Koc (L/kg)	Water Partition Coefficient log Kow (L/kg)	Water Solubility (mg/L)	Permeability Coefficient K_p (cm/hr)
Tetrachloroethene	127-18-4	165.83	7.20E-01	1.90E+01	1.60E+00	5.00E-02	9.50E-06	9.50E+01	3.40E+00	2.10E+02	3.30E-02
Trichloroethene	79-01-6	131.39	4.00E-01	6.90E+01	1.50E+00	6.90E-02	1.00E-05	6.10E+01	2.40E+00	1.30E+03	1.20E-02
cis-1,2- Dichloroethene	156-59-2	96.94	1.70E-01	2.00E+02	1.30E+00	8.80E-02	1.10E-05	4.00E+01	1.90E+00	6.40E+03	1.10E-02
Vinyl chloride	75-01-4	62.5	1.10E+00	3.00E+03	9.10E-01	1.10E-01	1.20E-05	2.20E+01	1.60E+00	8.80E+03	8.40E-03
Carbon Tetrachloride	56-23-5	153.82	1.10E+00	1.20E+02	1.60E+00	5.70E-02	9.80E-06	4.40E+01	2.80E+00	7.90E+02	1.60E-02
Chloroform	67-66-3	119.38	1.50E-01	2.00E+02	1.50E+00	7.70E-02	1.10E-05	3.20E+01	2.00E+00	8.00E+03	6.80E-03

Source: Vapor Intrusion Screening Level (VISL) Calculator Version 3.4, June 2015 RSLs

Figures



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Feet

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

Project No. **003978-00**
Revision No. **-**
Date **01/27/2023**

SITE LOCATION

FIGURE 1.1

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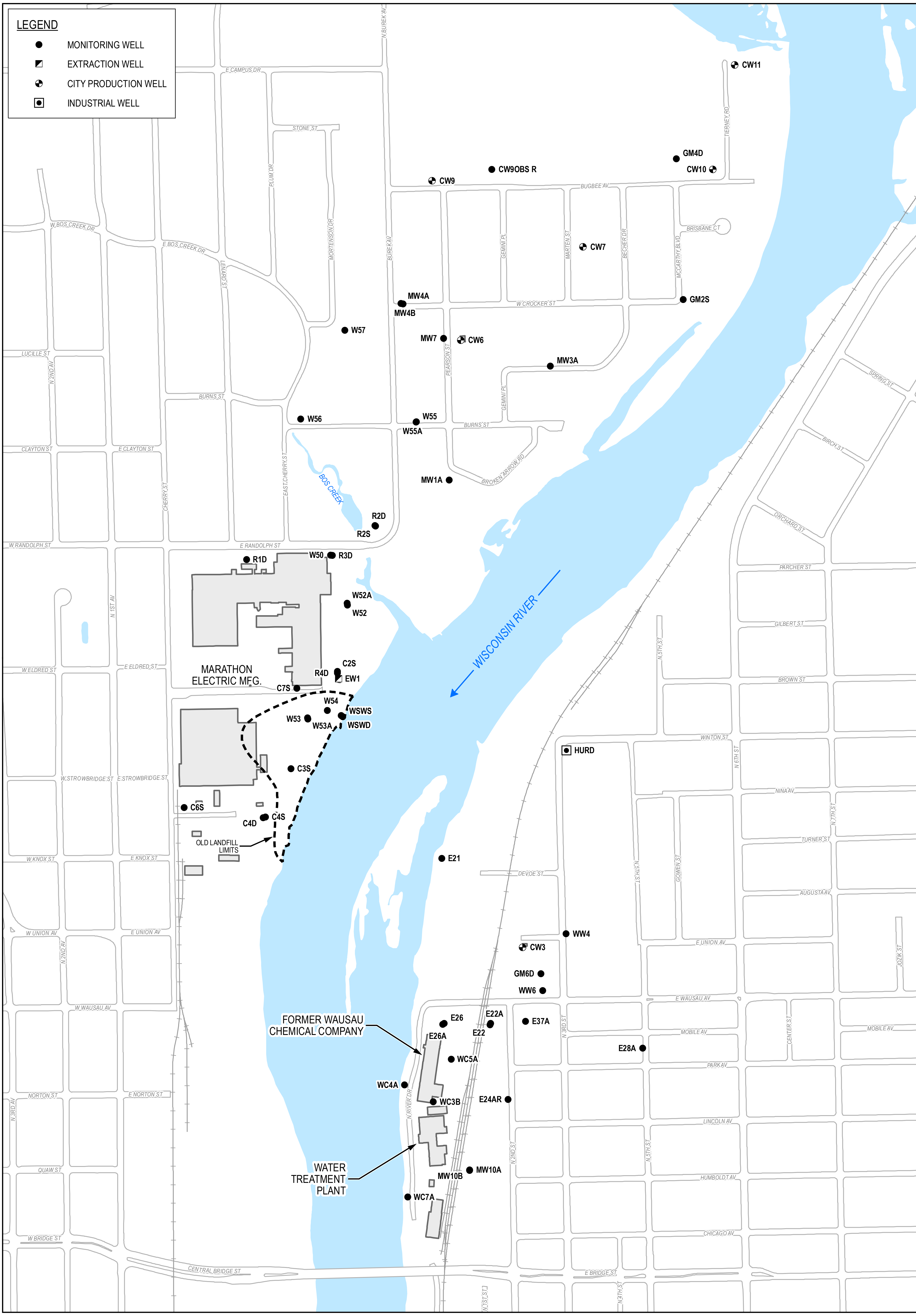

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SITE PLAN

Project No. 003978-00
Revision No. -
Date 01/27/2023

FIGURE 1.2

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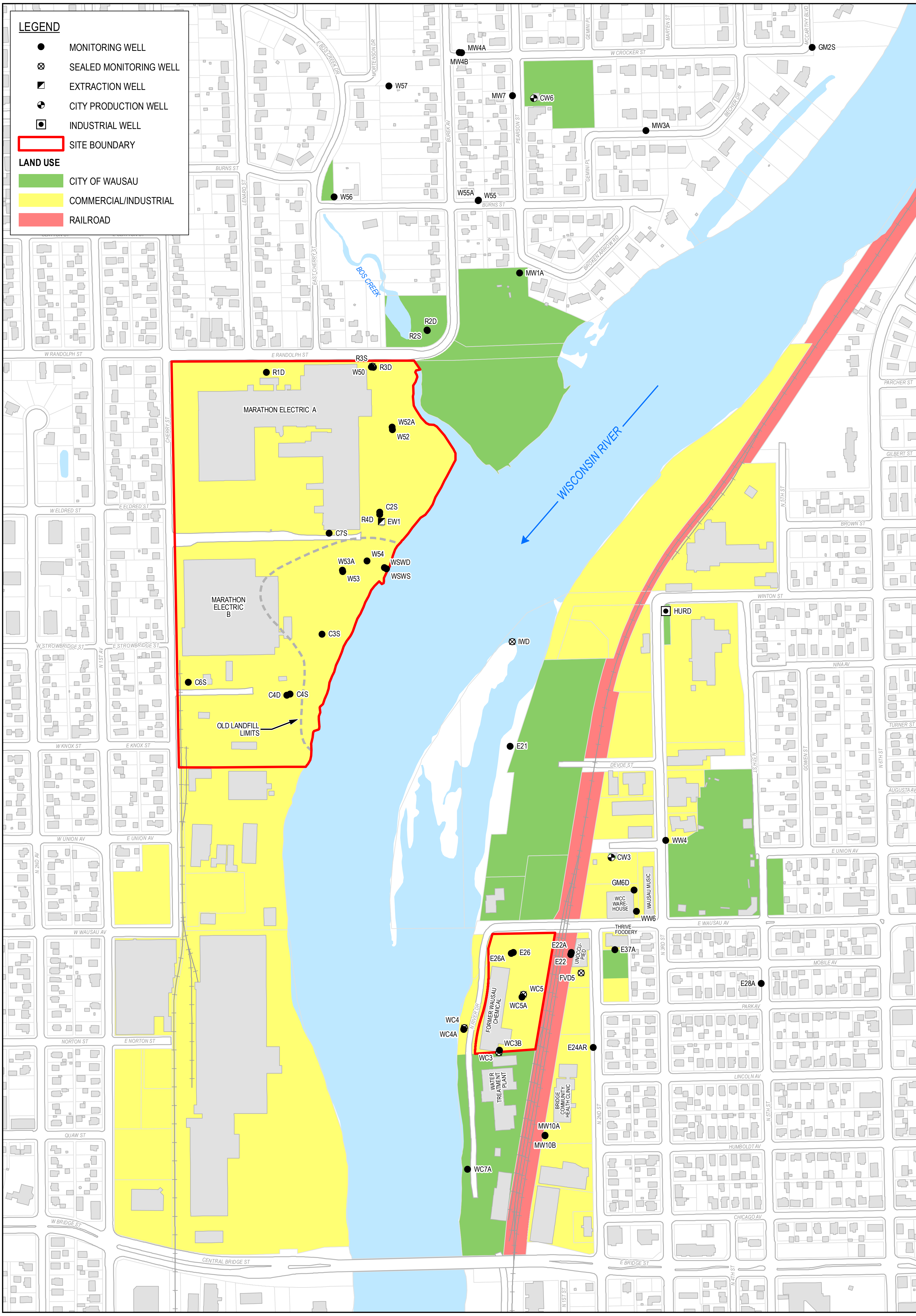

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Grid: NAD 1983 HARN WISCRS Marathon County Feet

GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

LAND USE

Project No. 003978-00
Revision No. -
Date 01/27/2023

FIGURE 1.3

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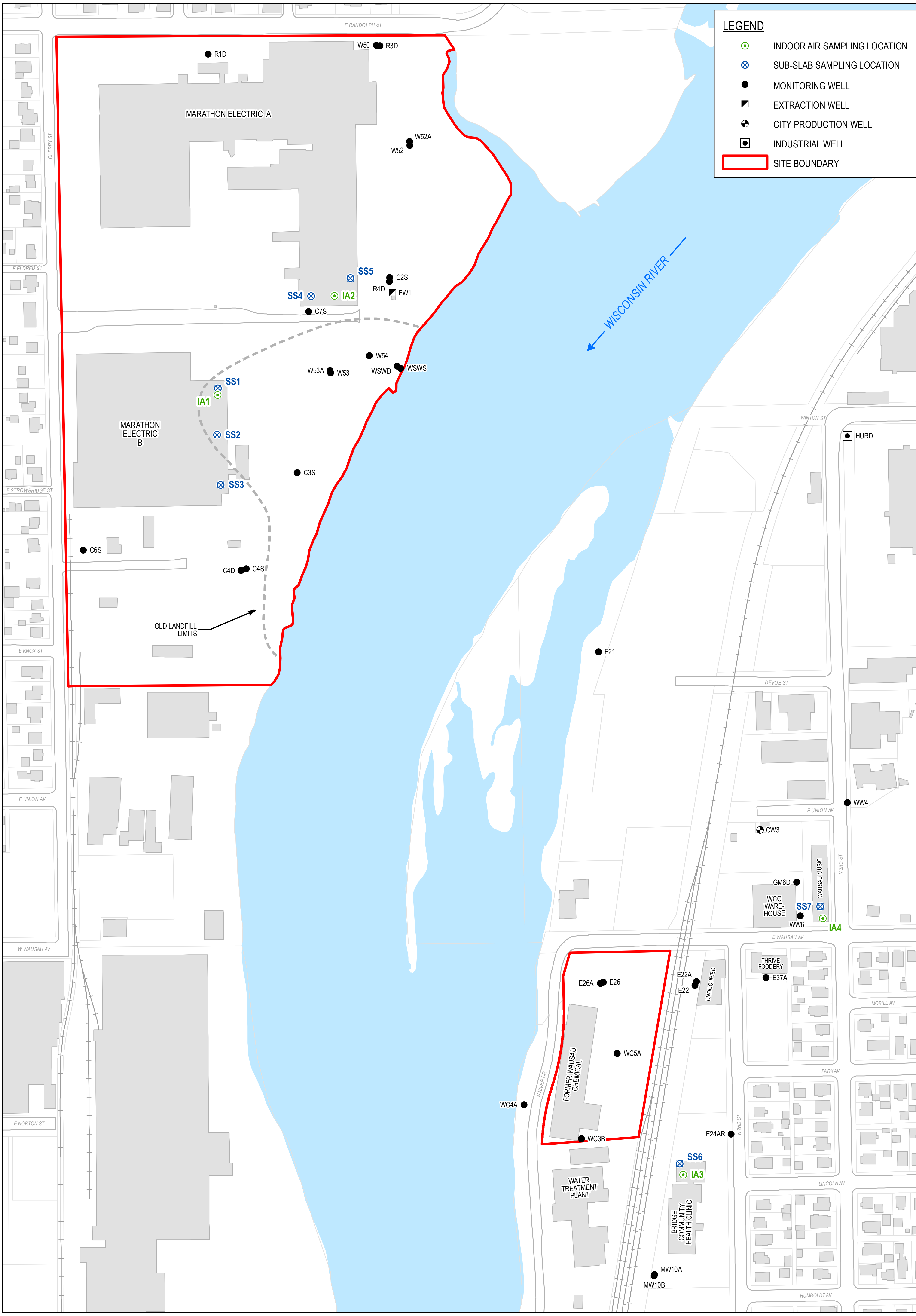

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Feet

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

PROPOSED SUB-SLAB VAPOR SAMPLE LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/27/2023

FIGURE 3.1

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Map Projection: Lambert Conformal Conic
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Grid: NAD 1983 HARN WISCRS Marathon County Feet

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

PREFERENTIAL PATHWAY INVESTIGATION SAMPLING LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/27/2023

FIGURE 3.2

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Print date: 27 Jan 2023 - 15:33

Data source: Marathon County. Created by: rjcoy

Appendices

Appendix A

GHD Vapor Intrusion Evaluation Summary Report 2019

January 29, 2020

Reference No. 003978

Sheri Bianchin
Remedial Project Manager
EPA Region 5
77 West Jackson Blvd.
Chicago, IL 60604-3590

Matt Thompson
Hydrogeologist
Wisconsin Department of Natural Resources
1300 W. Clairemont Avenue
Eau Claire, Wisconsin 54701

Dear Ms. Bianchin and Mr. Thompson:

Re: Vapor Intrusion Evaluation Summary Report
Wausau Water Supply NPL Site
Wausau, Wisconsin

1. Overview

From March 2017 to April 2019 GHD performed additional field work to supplement existing Site data in an effort to better understand the potential for vapor intrusion (VI) risk in areas adjacent to the known groundwater plume footprints at the Site. These activities are listed below and summarized in greater detail in the sections to follow. Figure 1 presents a Site Plan.

1. Installed temporary monitoring wells and collected groundwater samples for volatile organic compound (VOC) analysis to further delineate groundwater impacts in residential and commercial/industrial areas on the West Bank and East Bank. This was conducted in March 2017 and is summarized in Section 1.2.
2. Installed vapor probes and collected vapor samples to delineate the horizontal and vertical extent of potential VOCs in the vadose zone on the West Bank and East Bank. Two sampling rounds were conducted in March 2017 and August 2017 as summarized in Section 1.3.
3. Collected sub-slab and indoor air samples at select residential and commercial/industrial buildings on the West Bank and East Bank. West Bank samples were collected on two occasions in March 2017 and August 2017. The West Bank results are summarized in Section 1.4. East Bank sub-slab and indoor air sampling has occurred on six occasions from April 2017 through September 2019. These results are summarized in Section 1.4.

1.1 Additional Groundwater Sampling Results

Additional groundwater delineation was conducted to the east of monitoring well E24AR on the East Bank and north of Marathon Electric property on the West Bank in March 2017. These groundwater samples were collected from temporary wells that were removed after sample collection. VOC data from these locations were used to confirm and establish the extent of potential groundwater vapor sources.

1.1.1 East Bank Groundwater Sampling

On March 6 and 7, 2017, groundwater samples were collected on the East Bank to further delineate the eastern extent of the groundwater plume. Temporary wells were installed at nine locations (E1 through E9) as shown on Figure 2. Samples from these wells were analyzed for tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (c12DCE), and vinyl chloride.

While groundwater samples from temporary wells E1 through E7 all had VOC detections, only temporary wells E2 (15 µg/L TCE) and E4 (5.4 µg/L vinyl chloride) had VOC concentrations that slightly exceeded the VI screening level for groundwater[1]. Temporary wells E8 and E9 had no detections. All East Bank groundwater sampling results are shown in Table 1.

The East Bank groundwater delineation sampling results indicated that the eastern limit of the VOC plume was between N 2nd Street and N. 3rd Street, and the southern limit was north of Lincoln Avenue (see Figure 2).

1.1.2 West Bank Groundwater Sampling

Potential VI sources on the West Bank are related to shallow groundwater and soils in the former City landfill. On March 8 and 9, 2017, groundwater samples were collected adjacent to Marathon Electric building "A" to further delineate the groundwater plume adjacent to and immediately downgradient from the fill area. Additionally, shallow groundwater samples were collected at select locations north of Marathon Electric property to confirm that the shallow aquifer is not impacted in that area. A total of seven temporary wells (W1 through W7), as shown on Figure 2, were installed on the West Bank. Samples from these wells were analyzed for TCE, c12DCE, CT, chloroform, and vinyl chloride.

Of the groundwater samples collected from the seven temporary wells on the West Bank, only two samples contained VOCs at detectable concentrations. Temporary well W2 had a TCE detection of 1.0 µg/L. Temporary well W4, directly downgradient from W2 had a chloroform concentration on 2.1 µg/L. None of the groundwater samples collected from the West Bank temporary wells had VI screening level exceedances. All West Bank groundwater sampling results are shown in Table 1.

The West Bank groundwater delineation sampling results indicated that the VOC plume is primarily within the deeper portion of the aquifer and VOCs in the shallow portion of the aquifer do not extend far from the landfill.

1.2 Soil Vapor Sampling Results

Vapor samples were collected at each of the East Bank and West Bank groundwater delineation temporary well locations. Vapor probes were constructed with 6-inch stainless steel screen implants attached to ¼" polyethylene tubing. Two vapor probe sampling events were conducted in the spring and

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[1] USEPA VISL Calculator with 10-5 additional cancer risk.

late summer of 2017. All vapor probes were sampled using stainless steel vacuum canisters and samples were analyzed by the TO-15 method. Vapor probe locations are depicted on Figure 2.

1.2.1 East Bank Vapor Probes

In March 2017, vapor probes were installed at each of the nine East Bank groundwater sampling locations described in Section 1.1.1. For locations where the depth to groundwater was greater than 20 feet (E2 and E4 through E9), vapor sample collection was attempted at two depths, one just above the water table and the other at 8.5 to 9 ft bgs (assumed basement depth). At the two locations where the water table was 20 ft bgs or shallower (E1 and E3), only one sample was collected. These probes were screened from 8.5 to 9 ft bgs as well. There were nine total shallow probes and seven total deep probes (16 probes total) on the East Bank. Samples were collected using vacuum canisters and were analyzed by the TO-15 method. East Bank vapor analytes include PCE, TCE, c12DCE, and vinyl chloride.

March 2017 East Bank vapor probe sampling results are presented in Table 2. The shallow probe at location E7 had water in the screened interval and was not sampled. All 15 of the remaining probes were successfully sampled. All 15 probes had detectable VOC concentrations, although none exceeded their respective residential or small industrial screening levels.

On August 1, 2017, GHD collected a second round of soil vapor samples from the East Bank probes. August 2017 East Bank vapor probe sampling results are also provided in Table 2. The single probe installed at E3 and both shallow and deep probes installed at E6 were not sampled because they were removed due to road construction. The shallow probe installed at E7 was not sampled due to the presence of water in the probe. Of the remaining 12 probes, all had detectable VOC concentrations, although none exceeded their respective residential or small industrial screening levels.

1.2.2 West Bank Vapor Probes

In March 2017, vapor probes were installed at each of the seven West Bank groundwater sampling locations described in Section 1.1.2. For locations where the depth to groundwater was greater than 20 feet (W1 through W4 and W7), vapor samples were attempted to be collected at two levels, one just above the water table and the other at 8.5 to 9 ft. bgs (assumed basement depth). At the two locations where the water table was 20 ft. bgs or shallower (W5 and W6), only one sample was collected. These probes were screened from 5.5 to 6 ft. bgs. There were seven total shallow probes and five total deep probes (12 probes total). Samples were collected using vacuum canisters and were analyzed by the TO-15 method. West Bank vapor analytes include TCE, c12DCE, vinyl chloride, CT, and chloroform.

On March 13 and 14, 2017, GHD collected soil vapor samples from the 12 West Bank probes and these sampling results are presented in Table 2. All probes had detectable VOC concentrations, although none exceeded their respective residential or non-residential screening levels.

On August 1, 2017, GHD collected a second round of soil vapor samples from the 12 West Bank probes. August 2017 West Bank vapor probe sampling results are included in Table 2. W6 was not sampled due to water in the probe. All of the 11 probes sampled had detectable VOC concentrations, although none exceeded their respective USEPA residential or large industrial screening levels.

1.3 Sub-slab and Indoor Air Sampling Results

Sub-slab vapor and indoor air sampling was conducted at residential and commercial buildings that were identified as potential vapor intrusion risks based on their proximity to source areas or elevated groundwater concentrations. The scope of this evaluation included assessments of residential and commercial/industrial buildings for occupancy, construction, basements, ventilation, and presence of radon mitigation system. Where access was granted, sub-slab/indoor air locations were sampled at least twice to confirm the initial results.

1.3.1 East Bank Sub-slab and Indoor Air Sampling

The initial vapor sampling on the East Bank occurred at five residential properties along North 2nd Street and one commercial property (Bridge Community Clinic). Sample locations are shown on Figure 3. Sampling rounds were conducted in April, May, and July 2017, and in March 2018. Two to four samples were collected from the six locations and each sample was analyzed using the TO-15 method for PCE, TCE, c12DCE, and vinyl chloride. Sub-slab and indoor air laboratory results are presented in Table 3.

Based on an additional groundwater result obtained from monitoring well WW-6 in the fall of 2017, an additional residential property (2108 N. 3rd St.) was added to the March 2018 sampling round. Subsequent monitoring events included the commercial property at 200 E. Wausau Avenue (D&J Rentals) and a residential property at 2103 N. 3rd Street. Two adjacent residential properties and one commercial property (Thrive Foodery) were contacted to request access for sampling, but access was not obtained. Sub-slab and indoor air results for all sampling events are included in Table 3. A summary of the sequence of sampling events and the locations sampled, as well as a list of the properties that were contacted but either did not respond or denied access is provided in Table 4..

1.3.1.1 East Bank Residential Sub-slab and Indoor Air Results

USEPA/WDNR sub-slab screening levels are included on Table 3. The residential sub-slab screening level for TCE (70 µg/m3) was exceeded in three of the 18 samples collected and each of the three exceedances were from a different location. The highest sub-slab TCE concentration was 160 µg/m3. However, three other samples from the same location did not exceed 12 µg/m3. The screening levels for PCE and vinyl chloride were not exceeded in any of the sub-slab samples.

A total of 23 residential indoor air samples were collected from eight homes. The indoor air action levels were not exceeded in any of the samples except for one basement sample that slightly exceeded the TCE action level of 2.1 µg/m3. Two subsequent TCE results for that location (1917 N. 2nd St.) were 0.28 µg/m3 and 1.6 µg/m3. The basement at 1917 N. 2nd St. is unfinished and is used solely for laundry and storage.

1.3.1.2 East Bank Small Commercial Sub-slab and Indoor Air Results

Two small commercial properties were evaluated as part of the sub-slab/indoor air investigation. Samples were collected in April and July, 2017, at the Bridge Community Clinic and samples were collected in April and September, 2019, at J & D Rentals. The lab results are included in Table 3. The basements of both of these locations are near the water table and PCE and TCE were detected in all sub-slab samples. Concentrations were assessed relative to the USEPA/WDNR small commercial screening levels and none of the results exceeded an action level.

PCE and TCE were also detected in all of the indoor air samples collected in the basement level of the two buildings, but all concentrations were far below their respective action levels, as shown on Table 3.

Based on the East Bank residential and commercial indoor air results, there does not appear to be a health risk at the tested properties related to potential vapor intrusion of Site chemicals. No additional vapor intrusion evaluation is recommended.

1.3.2 West Bank Sub-slab and Indoor Air Sampling

Sub-slab and indoor air sampling on the West Bank was limited to Marathon Electric (Regal) property. Groundwater results from residential areas hydraulically downgradient from Marathon Electric revealed that the shallow groundwater is not impacted. Thus, additional vapor intrusion evaluation of the West Bank residential area is not needed.

Based on the close proximity of Marathon Electric buildings to the former City landfill, sub-slab sampling was performed at six total locations in the two buildings closest to the former landfill. Sub-slab and indoor air sample locations are shown on Figure 4. Two sampling events were performed in March and August 2017. All samples were collected using vacuum canisters and laboratory analysis was performed using the TO-15 method. West Bank vapor analytes included TCE, c12DCE, CT, chloroform, and vinyl chloride.

1.3.2.1 West Bank Sub-slab and Indoor Air Results

West Bank sub-slab results are presented Table 5. The vapor data were compared to sub-slab screening levels and indoor air action levels for large industrial buildings. The sub-slab TCE concentrations from both sampling events at SS-2 beneath Building B and at SS-5 beneath Building A exceeded the screening level of 880 µg/m3. Chloroform and CT were also detected in some of the sub-slab samples, but all concentrations were below their respective screening levels.

Indoor air samples were collected from one location inside each building, as shown on Figure 4. TCE, CT, and chloroform were detected in both sampling events, but all concentrations were far below the indoor air action levels for large industrial buildings.

Since the indoor air concentrations did not suggest a health risk to Marathon Electric employees, no additional vapor intrusion evaluation is recommended on the West Bank.

Groundwater VOC concentrations are expected to continue their long term decline. However, GHD will continue evaluating groundwater data and if concentrations increase in the shallow aquifer, potential additional vapor intrusion evaluation will be conducted.

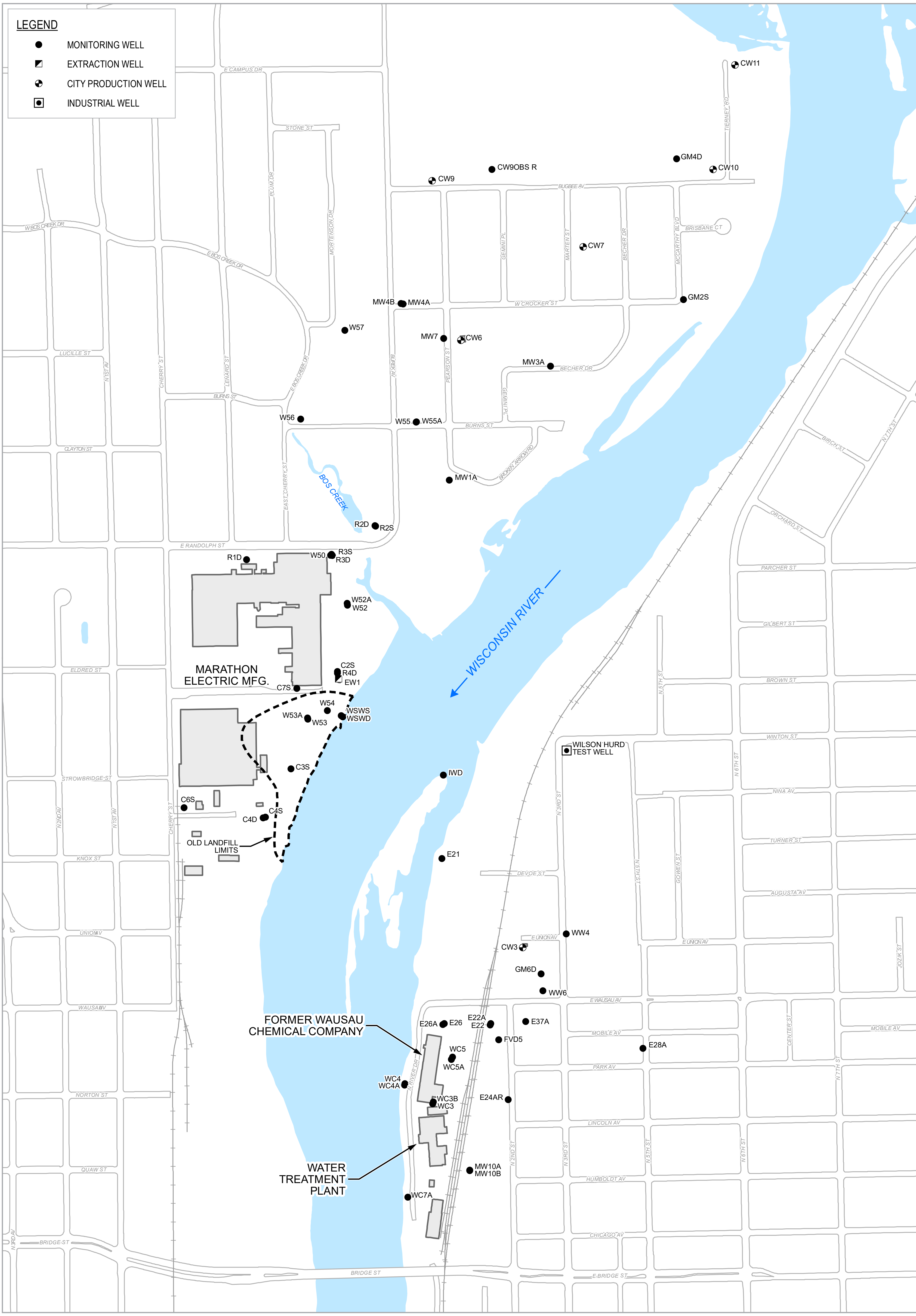
Sincerely,

GHD

Charles Ahrens Kiel Jenkin

CA/sb/1

Encl.



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Horizontal Datum: North American 1983 HARN
Grid: NAD 1983 HARN WISCRS Marathon County Feet

GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SITE PLAN

Project No. **003978-00**
Revision No. **-**
Date **01/28/2020**

FIGURE 1

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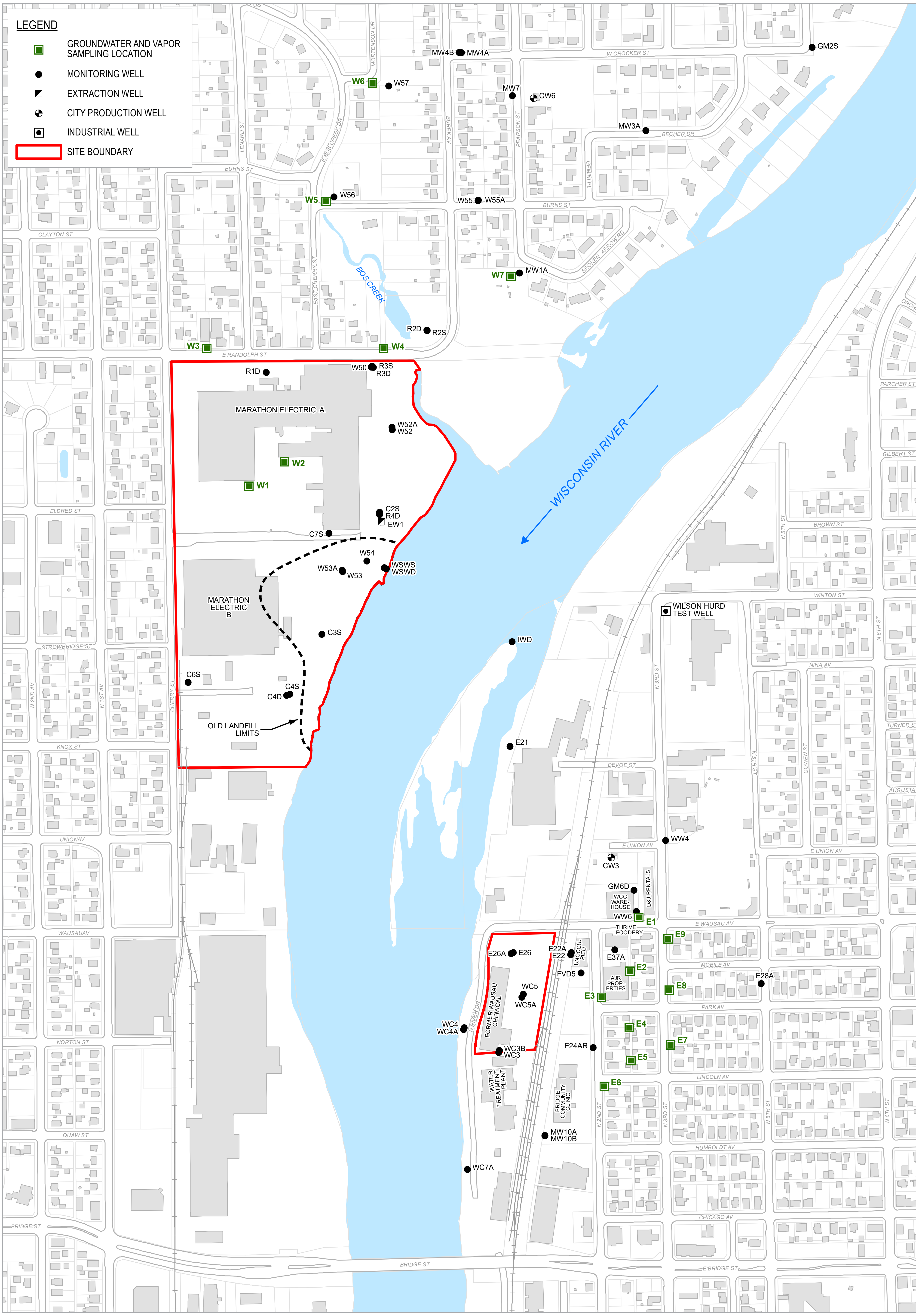

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SHALLOW AQUIFER DELINEATION LOCATIONS AND SOIL VAPOR PROBE LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/28/2020

FIGURE 2

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

EAST BANK SUB-SLAB VAPOR AND INDOOR AIR SAMPLE LOCATIONS

Project No. 003978-00
Revision No. -
Date 01/28/2020

FIGURE 3

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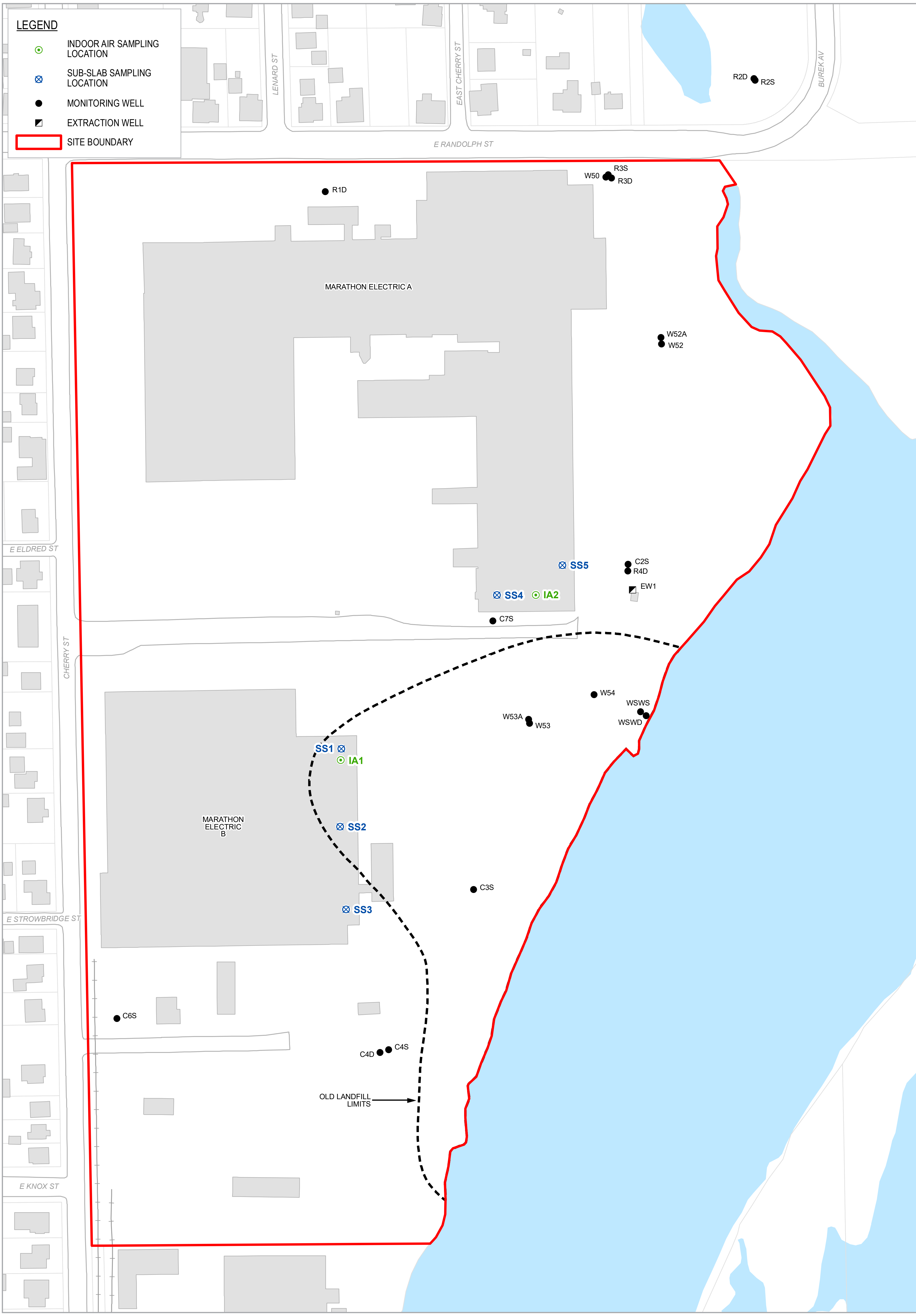

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GHD

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

WEST BANK SUB-SLAB VAPOR AND INDOOR AIR SAMPLE LOCATIONS

Project No. **003978-00**
Revision No. **-**
Date **01/28/2020**

FIGURE 4

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Table 1

Groundwater Delineation Sample Results
Vapor Intrusion Evaluation
Wausau Water Supply NPL Site
Wausau, Wisconsin

East Bank	Date	Water Table Depth (ft bgs)	Sample Depth (ft bgs)	Units	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
E1 (Non-res)	3/6/2017	15	15 -19	µg/L	2.4	1.3	3.2	0.45 U	--	--
E2	3/7/2017	25	25-29	µg/L	4.9	**15**	43	0.90 U	--	--
E3 (Non-res)	3/6/2017	20	20-24	µg/L	6.2/6.1	12/13	14/15	0.60 J/0.69 J	--	--
E4	3/7/2017	28	28-32	µg/L	11	4.9	30	**5.4**	--	--
E5	3/7/2017	25	25-29	µg/L	6.0	1.2	5.3	0.45 U	--	--
E6	3/7/2017	25	25-29	µg/L	0.30 U	0.84 J	7.8	1.6	--	--
E7	3/6/2017	26	26-30	µg/L	0.51 J	0.33 U	0.30 U	0.45 U	--	--
E8	3/6/2017	26	26-30	µg/L	0.30 U	0.33 U	0.30 U	0.45 U	--	--
E9	3/6/2017	24	24-28	µg/L	0.30 U	0.33 U	0.30 U	0.45 U	--	--
West Bank										
W1 (Non-res)	3/8/2017	33	33-35	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
W2 (Non-res)	3/9/2017	30	31-35	µg/L	--	1.0	0.30 U	0.45 U	0.35 U	0.31 U
W3	3/9/2017	34	34-38	µg/L	--	0.33 U/0.33 U	0.30 U/0.30 U	0.45 U/0.45 U	0.35 U/0.35 U	0.31 U/0.31 U
W4	3/9/2017	23	23-25	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	2.1
W5	3/9/2017	9	10-12	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
W6	3/9/2017	9.5	10-12	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
W7	3/9/2017	28	29-32	µg/L	--	0.33 U	0.30 U	0.45 U	0.35 U	0.31 U
Residential Vapor Intrusion Screening Level (10E-05 target risk for carcinogens)				µg/L	**120**	**10**	**--**	**3.0**	**7.6**	**15**
Non-Residential Vapor Intrusion Screening Level (10E-05 target risk for carcinogens)				µg/L	**510**	**42**	**--**	**37**	**34**	**64**

Notes:

15 - indicates VI screening level exceeded

Screening levels are based on USEPA's VISL Calculator with 1.0E-05 additional cancer risk and a 1.0 Hazard Quotient for non-carcinogens

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

East Bank - March 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride
E1 S (Non-res)	3/9/2017	15	8.5 - 9	ug/m3	1,300	9.6	6.3 U	2.0 U
E2 S	3/9/2017	25	8.5 - 9	ug/m3	77	1.6	0.79 U	0.26 U
E2 D	3/9/2017	25	19.5 - 20	ug/m3	120	33	28	0.51 U
E3 S (Non-res)	3/9/2017	20	8.5 - 9	ug/m3	130	76	6.1	0.10 U
E4 S	3/9/2017	28	8.5 - 9	ug/m3	38	0.21 U	0.32 U	0.10 U
E4 D	3/9/2017	28	21.5 - 22	ug/m3	190	21	13	0.26 U
E5 S	3/10/2017	25	8.5 - 9	ug/m3	100	0.99	0.32 U	0.10 U
E5 D	3/10/2017	25	21.5 - 22	ug/m3	160	8.6	0.51	0.10 U
E6 S	3/10/2017	25	8.5 - 9	ug/m3	69	1.8	0.32 U	0.10 U
E6 D	3/10/2017	25	21.5 - 22	ug/m3	750/680	27/26	7.4/7.0	0.68 U
E7 S	3/10/2017	26	8.5 - 9	ug/m3	W	W	W	W
E7 D	3/10/2017	26	21.5 - 22	ug/m3	96	7.2	0.35	0.10 U
E8 S	3/10/2017	26	8.5 - 9	ug/m3	25	0.43 U	0.63 U	0.20 U
E8 D	3/10/2017	26	21.5 - 22	ug/m3	160	17	0.63 U	0.20 U
E9 S	3/10/2017	24	8.5 - 9	ug/m3	160	0.43 U	0.63 U	0.20 U
E9 D	3/10/2017	24	21.5 - 22	ug/m3	170	25	1.2	0.10 U
Residential Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**1,400**	**70**	**--**	**56**
Small Industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**5,840**	**290**	**--**	**930**

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

East Bank - August 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride
E1 S (Non-res)	8/1/2017	15	8.5 - 9	ug/m3	1,700/1,900	24/23	3.4 U/1.2 J	2.7 U/0.74 U
E2 S	8/1/2017	25	8.5 - 9	ug/m3	43	0.75 U	0.95 U	0.74 U
E2 D	8/1/2017	25	19.5 - 20	ug/m3	51	46	39	0.74 U
E3S (Non-res)	8/1/2017	20	8.5 - 9	ug/m3	NA	NA	NA	NA
E4 S	8/1/2017	28	8.5 - 9	ug/m3	25	0.75 U	0.95 U	0.74 U
E4 D	8/1/2017	28	21.5 - 22	ug/m3	2.3 J	1.2 J	0.95 U	0.74 U
E5 S	8/1/2017	25	8.5 - 9	ug/m3	66/64	0.75 U/0.75 U	0.95 U/0.95 U	0.74 U/0.74 U
E5 D	8/1/2017	25	21.5 - 22	ug/m3	170	5.4	0.95 U	0.74 U
E6 S	8/1/2017	25	8.5 - 9	ug/m3	NA	NA	NA	NA
E6 D	8/1/2017	25	21.5 - 22	ug/m3	NA	NA	NA	NA
E7 S	8/1/2017	26	8.5 - 9	ug/m3	W	W	W	W
E7 D	8/1/2017	26	21.5 - 22	ug/m3	410	4.8	0.95 U	0.74 U
E8 S	8/1/2017	26	8.5 - 9	ug/m3	30	1.2 J	0.95 U	0.74 U
E8 D	8/1/2017	26	21.5 - 22	ug/m3	92	10	0.95 U	0.74 U
E9 S	8/1/2017	24	8.5 - 9	ug/m3	230	1.6 J	0.95 U	0.74 U
E9 D	8/1/2017	24	21.5 - 22	ug/m3	220	7.8	0.96 J	0.74 U
Non-industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**1,400**	**70**	**--**	**56**
Small Industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**5,840**	**290**	**--**	**930**

Notes:

NA - Probes E3, E6S, and E6D were removed by road construction prior to the August 2017 sampling event

W - Probe E7S could not be sampled during either sampling event due to water in the probe

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

West Bank - March 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
W-1S (Indust)	3/13/2017	33	8.5 - 9	ug/m3	6.1	0.095 U	0.074 U	0.38 J	0.56
W-1D (Indust)	3/13/2017	33	29.5 - 30	ug/m3	6.4	0.095 U	0.074 U	0.49 J	0.12 J
W-2S (Indust)	3/13/2017	30	8.5 - 9	ug/m3	94	0.16 J	0.12 U	0.74 J	0.0778 J
W-2D (Indust)	3/13/2017	30	26.5 - 27	ug/m3	86	0.18 J	0.093 U	0.21 J	0.46 J
W-3S	3/14/2017	34	8.5 - 9	ug/m3	10	0.095 U	0.074 U	0.25 J	0.19 J
W-3D	3/14/2017	34	30.5 - 31	ug/m3	32	0.13 J	0.074 U	0.34 J	0.13 J
W-4S	3/14/2017	21	8.5 - 9	ug/m3	0.099 J	0.095 U	0.074 U	0.094 U	3.3
W-4D	3/14/2017	21	18.5 - 19	ug/m3	0.13 J	0.095 U	0.074 U	0.094 U	14
W-5S	3/14/2017	9	5.5 - 6	ug/m3	9.0	0.095 U	0.074 U	0.28 J	0.13 J
W-6S	3/14/2017	9.5	5.5 - 6	ug/m3	2.2	0.095 U	0.074 U	0.74	0.35 J
W-7S	3/14/2017	28	8.5 - 9	ug/m3	7.3	0.095 U	0.074 U	0.12 J	<0.073
W-7D	3/14/2017	28	24.5 - 25	ug/m3	1.8	0.095 U	0.074 U	0.10 J	0.10 J
Residential Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**70**	**--**	**57**	**127**	**43**
Large Industrial Screening Level (10-5 Additional Risk) (0.01 attenuation factor)				ug/m3	**880**	**--**	**2,800**	**2,050**	**540**

Table 2

Vapor Probe Results - East Bank and West Bank Locations
Wausau Water Supply NPL Site
Wausau, Wisconsin

West Bank - August 2017	Date	Water Table Depth (ft bgs)	Vapor Probe Screen Depth (ft bgs)	Units	Trichloroethene	cis-1,2-Dichloroethene	Vinyl chloride	Carbon tetrachloride	Chloroform
W-1S (Indust)	8/1/2017	33	8.5 - 9	ug/m3	0.77 J/0.75 U	0.95 U/0.95 U	0.74 U/0.74 U	0.94 U/0.94 U	0.73 U/0.73 U
W-1D (Indust)	8/1/2017	33	29.5 - 30	ug/m3	170	0.95 U	0.74 U	4.5 J	1.3 J
W-2S (Indust)	8/1/2017	30	8.5 - 9	ug/m3	160	0.95 U	0.74 U	0.94 U	0.73 U
W-2D (Indust)	8/1/2017	30	26.5 - 27	ug/m3	100	0.95 U	0.74 U	0.94 U	0.73 U
W-3S	8/1/2017	34	8.5 - 9	ug/m3	4.5	0.95 U	0.74 U	0.94 U	0.75 J
W-3D	8/1/2017	34	30.5 - 31	ug/m3	13	0.95 U	0.74 U	0.94 U	0.73 U
W-4S	8/1/2017	21	8.5 - 9	ug/m3	0.75 U/0.75 U	0.95 U/0.95 U	0.74 U/0.74 U	0.94 U/0.94 U	20/14
W-4D	8/1/2017	21	18.5 - 19	ug/m3	65	0.95 U	0.74 U	1.3 J	21
W-5S	8/1/2017	9	5.5 - 6	ug/m3	4.5	0.95 U	0.74 U	0.94 U	0.73 U
W-6S	8/1/2017	9.5	5.5 - 6	ug/m3	W	W	W	W	W
W-7S	8/1/2017	28	8.5 - 9	ug/m3	7.8	0.95 U	0.74 U	0.94 U	0.73 U
W-7D	8/1/2017	28	24.5 - 25	ug/m3	1.8 J	0.95 U	0.74 U	0.94 U	0.73 U
Non-industrial Screening Level (10-5 Additional Risk) (0.03 attenuation factor)				ug/m3	**70**	**--**	**57**	**127**	**43**
Large Industrial Screening Level (10-5 Additional Risk) (0.01 attenuation factor)				ug/m3	**880**	**--**	**2,800**	**2,050**	**540**

Notes:

W - Probe W6S could not be sampled during the August 2017 sampling event due to water in the probe
Screening levels are based on USEPA's VISL Calculator with a 10-05 target risk for carcinogens; and a 1.0 Hazard Quotient

Table 3

East Bank Subslab and Indoor Air Lab Results
Wausau Water Supply NPL Site
Wausau. Wisconsin

SUB-SLAB

	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
(Bodenheimer)						
1901 N. 2nd St.	4/4/2017	Subslab	130	11	9.6	0.074 U
1901 N. 2nd St.	7/31/2017	Subslab	7.8	1.4 J	1.0 J	0.074 U
1901 N. 2nd St.	3/27/2018	Subslab	140	56	68	0.074 U
(Hang)						
1905 N. 2nd St.	5/15/2017	Subslab	160	0.18	0.095 U	0.074 U
1905 N. 2nd St.	3/28/2018	Subslab	220	**84**	3.2	0.074 U
(Westberg)						
1909 N. 2nd St.	5/15/2017	Subslab	47	0.40	0.095 U	0.074 U
1909 N. 2nd St.	7/31/2017	Subslab	57	0.86 J	0.095 U	0.074 U
1909 N. 2nd St.	3/27/2018	Subslab	100	8.6	0.095 U	0.074 U
(Viergutz)						
1915 N. 2nd St.	4/4/2017	Subslab	63	3.5	0.095 U	0.074 U
1915 N. 2nd St.	7/31/2017	Subslab	42	1.0 J	0.095 U	0.074 U
1915 N. 2nd St.	3/27/2018	Subslab	65	42	0.095 U	0.074 U
(Krause)						
1917 N. 2nd St.	4/4/2017	Subslab	110	12	0.52	0.086 J
1917 N. 2nd St.	5/15/2017	Subslab	68	12	0.095 U	0.074 U
1917 N. 2nd St.	7/31/2017	Subslab	49	3.3	0.095 U	0.074 U
1917 N. 2nd St.	3/27/2018	Subslab	76	**160**	2.8 J	0.074 U
Sub-slab Residential Screening Level (0.03 attenuation factor)			**1,400**	**70**	**--**	**57**

INDOOR AIR

	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
(Bodenheimer)						
1901 N. 2nd St.	4/4/2017	Basement	0.15 J	0.075 U	0.095 U	0.074 U
1901 N. 2nd St.	7/31/2017	Basement	0.44 J	0.075 U	0.095 U	0.074 U
1901 N. 2nd St.	3/27/2018	Basement	0.38 J	0.15 J	0.095 U	0.074 U
(Hang)						
1905 N. 2nd St.	5/15/2017	1st Floor	0.14 J	0.075 U	0.095 U	<0.074
1905 N. 2nd St.	3/28/2018	1st Floor	0.11 J	0.075 U	0.095 U	0.074 U
(Westberg)						
1909 N. 2nd St.	5/15/2017	1st Floor	0.31 J	0.075 U	0.095 U	0.074 U
1909 N. 2nd St.	7/31/2017	1st Floor	0.28 J	0.075 U	0.095 U	0.074 U
1909 N. 2nd St.	3/27/2018	1st Floor	0.31 J	0.20 J	0.095 U	0.074 U
(Viergutz)						
1915 N. 2nd St.	4/4/2017	1st Floor	1.1	0.33	0.095 U	0.074 U
1915 N. 2nd St.	7/31/2017	1st Floor	0.24 J	0.075 U	0.095 U	0.074 U
1915 N. 2nd St.	3/27/2018	1st Floor	0.65	0.52	0.099 J	0.074 U
(Krause)						
1917 N. 2nd St.	4/4/2017	1st Floor	0.70	1.8	0.42	0.074 U
1917 N. 2nd St.	5/15/2017	1st Floor	0.28 J	0.14 J	0.095 U	0.074 U
1917 N. 2nd St.	7/31/2017	1st Floor	0.56	0.075 U	0.095 U	0.074 U
1917 N. 2nd St.	3/27/2018	1st Floor	0.65	0.86	0.40	0.074 U
(Krause)						
1917 N. 2nd St.	5/15/2017	Basement	1.2	**2.9**	0.68	0.074 U
1917 N. 2nd St.	7/31/2017	Basement	0.38 J	0.28	0.095 U	0.074 U
1917 N. 2nd St.	3/27/2018	Basement	0.99	1.6	0.75	0.074 U
Residential Indoor Air Action Level			**42**	**2.1**	**--**	**1.7**

Note: All units µg/m3

Table 3

East Bank Subslab and Indoor Air Lab Results
Wausau Water Supply NPL Site
Wausau. Wisconsin

SUB-SLAB

(Steffen)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
2108 N 3rd St.	3/27/2018	Subslab	370	**120**	42	0.074 U
(Helke)						
2103 N. 3rd St	4/25/2019	Subslab	1.1U	0.75U	0.95U	0.74U
2103 N. 3rd St	9/24/2019	Subslab	1.1	0.32U	0.40U	0.66U
Sub-slab Residential Screening Level (0.03 attenuation factor)			**1,400**	**70**	**--**	**57**

INDOOR AIR

(Steffen)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
2108 N 3rd St.	3/27/2018	1st Floor	2.1	0.83	0.16 J	0.074 U
2108 N. 3rd St.	4/25/2019	1st Floor	2.4	0.65	0.095U	0.074U
2108 N. 3rd St.	4/25/2019	Basement	3.4	0.71	0.095U	0.074U
(Helke)						
2103 N. 3rd St.	4/25/2019	1st Floor	1.7	0.38	0.095U	0.074U
2103 N. 3rd St.	9/24/2019	1st Floor	0.69	0.039 J	0.095U	0.074U
Residential Indoor Air Action Level			**42**	**2.1**	**--**	**1.7**

Commercial Properties

SUB-SLAB

(Bridge Clinic)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
Bridge Comm. Clinic	4/4/2017	Subslab	3,000	58	7.6 U	5.9 U
Bridge Comm. Clinic	7/31/2017	Subslab	2,700	65	6.7 U	5.2 U
(D&J Rentals 200 E. Wausau Ave.)						
D&J Showroom	4/25/2019	Subslab	740	25	0.095U	0.074U
D&J South Storage	4/25/2019	Subslab	97	15	0.40 J	0.074U
D&J South Storage Dup.	4/25/2019	Subslab	100	16	1.6 J	0.074U
D&J Showroom	9/24/2019	Subslab	1,100	37	0.40U	0.66U
D&J South Storage	9/24/2019	Subslab	240	11	1.1 J	0.074U
D&J South Storage Dup	9/24/2019	Subslab	220	10	1.1 J	0.074U
Small Commercial Sub-slab Screening Level (0.03 attenuation factor)			**6,000**	**290**	**--**	**930**

INDOOR AIR

(Bridge Clinic)	Date	Sample Location	Tetrachloroethene	Trichloroethene	c-1,2-Dichloroethene	Vinyl chloride
Bridge Comm. Clinic	4/4/2017	Basement	16	0.44	0.095 U	0.074 U
Bridge Comm. Clinic	7/31/2017	Basement	2.1	0.34	0.095 U	0.074 U
(D&J Rentals 200 E. Wausau Ave.)						
D&J - Showroom	4/25/2019	Basement	0.68	0.098	0.95U	0.74U
D&J - Showroom	9/24/2019	Basement	2.2	0.088	0.04U	0.066U
Small Commercial Indoor Air Action Level			**180**	**8.8**	**--**	**28**

Note: All units µg/m3

Screening Levels and Action Levels are from Wisconsin DNR "WI Vapor Quick Look-Up Table, Indoor Air Vapor Action Levels and Vapor Risk Screening Levels. Based on November 2017 U.S.EPA Regional Screening Levels.

Table 4

Summary of Property Owner Contacts and Sequence of Sub-slab and Indoor Air Sampling
Wausau Water Supply NPL Site
Wausau, Wisconsin

Sampling Event	Date	Properties Contacted to Request Access	Properties Sampled	Properties Not Responding or Declined Access
Round 1	4/4/2017	1901, 1905, 1909, 1915, and 1917 N. 2nd Street, Bridge Comm. Clinic	1901, 1915, and 1917 N. 2nd Street, Bridge Comm. Clinic	1905 and 1909 N. 2nd Street
Round 2	5/15/2017	1905, 1909, and 1917 N. 2nd Street	First sample from 1905 and 1909 N. 2nd St..Second sample from 1917 N. 2nd St..	None
Round 3	7/31/2017	1901, 1905, 1909, 1915, and 1917 N. 2nd Street, Bridge Comm. Clinic	Second sample from 1901, 1909, 1915 N. 2nd St. and Bridge Comm. Clinic. Third sample from 1917 N. 2nd St.	1905 N. 2nd St.
Round 4	3/27/2018	1901, 1905, 1909, 1915, and 1917 N. 2nd, Bridge Comm. Clinic and 2108 N. 3rd St.	Second sample from 1905 N. 2nd, Third samples from 1901, 1909, 1915 N. 2nd St.. Fourth sample from 1917 N. 2nd. Plus first sample from 2108 N. 3rd St.	None
Round 5	4/25/2019	2103, 2105, 2106, 2108 N. 3rd St, Thrive Foodery, D&J Rentals	2108 N. 3rd (second sample), 2103 N. 3rd, D&J Rentals	No responses from 2105 N. 3rd and Thrive Foodery. 2106 N. 3rd refused access
Round 6	9/24/2019	2103, 2105, 2106, 2108 N. 3rd St, Thrive Foodery, D&J Rentals	Second samples from 2103 N. 3rd and D&J Rentals	No responses from 2105 N. 3rd and Thrive Foodery. 2106 N. 3rd refused access

Table 5

West Bank Sub-slab Vapor and Indoor Air Results
Wausau Water Supply NPL Site
Wausau, Wisconsin

Sub-slab Regal - March 2017	**Date**	**Units**	**Trichloroethene**	**c-1,2-Dichloroethene**	**Vinyl chloride**	**Carbon tetrachloride**	**Chloroform**
SS-1 (north side Building B)	3/13/2017	ug/m3	270	1.3 J	0.37 U	0.47 U	0.40 J
SS-2 (middle Building B)	3/13/2017	ug/m3	**9,400**	150	21 U	1,200	220
SS-3 (south side Building B)	3/13/2017	ug/m3	0.78	0.95 U	0.74 U	0.62	0.17 J
SS-4 (southeast side Building A)	3/13/2017	ug/m3	220	0.99 J	0.25 U	5.3	1.5
SS-5 (southeast side Building A)	3/13/2017	ug/m3	**4,800**	17 U	13 U	17 U	41 J
Sub-slab Large Industrial Screening Level (0.01 attenuation factor)			**880**	**--**	**2,800**	**2,000**	**530**

Indoor Air Regal - March 2017							
Indoor Air - Building B	3/13/2017	ug/m3	1.6	0.095 U	0.074 U	0.44 J	0.15 J
Indoor Air - Building A	3/13/2017	ug/m3	0.82	0.095 U	0.074 U	0.42 J	0.14 J
Industrial Indoor Air Action Level			**8.8**	**--**	**28**	**20**	**5.3**

Outdoor Air near Building B	3/13/2017	ug/m3	0.075 U	0.095 U	0.074 U	0.41 J	0.093 J

Table 5

West Bank Sub-slab Vapor and Indoor Air Results
Wausau Water Supply NPL Site
Wausau, Wisconsin

Sub-slab Regal - August 2017	**Date**	**Units**	**Trichloroethene**	**c-1,2-Dichloroethene**	**Vinyl chloride**	**Carbon tetrachloride**	**Chloroform**
SS-1 (north side Building B)	8/1/2017	ug/m3	280	1.3 J	0.74 U	0.94 U	0.73 U
SS-2 (middle Building B)	8/1/2017	ug/m3	**15,000**	260	43 U	1,800	470
SS-3 (south side Building B)	8/1/2017	ug/m3	0.75 U	0.95 U	0.74 U	5.5	0.73 U
SS-4 (southeast Building A)	8/2/2017	ug/m3	9.4	0.95 U	0.74 U	0.94 U	0.73 U
SS-5 (southeast Building A)	8/1/2017	ug/m3	**4,900**	15 U	12 U	15 U	50 J
Sub-slab Large Industrial Screening Level (0.01 attenuation factor)			**880**	**--**	**2,800**	**2,000**	**530**

Indoor Air Regal - August 2017							
Indoor Air - Building B	8/1/2017	ug/m3	0.075 U	0.095 U	0.074 U	0.41 J	0.15 J
Indoor Air - Building A	8/1/2017	ug/m3	0.17 J	0.095 U	0.074 U	0.45 J	0.14 J
Industrial Indoor Air Action Level			**8.8**	**--**	**28**	**20**	**5.3**

Outdoor Air near Building B	8/1/2017	ug/m3	0.075 U	0.095 U	0.074 U	0.44 J	0.14 J

Notes:

4,800 - Result exceeded applicable screening level

J - Estimated value

Screening Levels and Action Levels are from Wisconsin DNR "WI Vapor Quick Look-Up Table, Indoor Air Vapor Action Levels and Vapor Risk Screening Levels. Based on November 2017 U.S.EPA Regional Screening Levels.

Appendix B

Quality Assurance Objectives

Appendix B Quality Assurance

1. Data Quality Objectives

The QA objective for this project is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and laboratory reporting that will provide results that can be used to make decisions regarding potential risks related to soil vapor intrusion of commercial/industrial and residential buildings. Shallow groundwater contaminants will be further delineated, vadose zone vapor will be characterized, and buildings will be assessed to determine occupancy and construction features.

The data will be used to support decisions about whether additional groundwater delineation is needed, if the vapor characterization area should be expanded, or if sub-slab and indoor air sampling should be conducted; and whether vapor intrusion mitigation should be pursued in buildings.

1.1 Precision

1.1.1 Field Precision Objectives

Field precision for measurements associated with groundwater monitoring and vapor sampling will be assessed through the collection and measurement of duplicate samples or calibration check solutions at a frequency of one per ten groundwater samples. The precision control limits for field measurements obtained during the field investigation activities are summarized in the field investigation SOPs in Appendix D.

1.1.2 Laboratory Precision Objectives

Precision in the laboratory will be assessed through the calculation of relative percent differences (RPDs) for replicate/duplicate samples. The equations for RPD calculations are presented in the laboratory SOP for each method, which are provided in Appendix B.

1.2 Accuracy

1.2.1 Field Accuracy Objectives

Groundwater sampling accuracy in the is assessed through the use of field and trip blank samples and is ensured by observing all sample handling procedures, preservation requirements, and holding time periods. Accuracy of field measurements associated with groundwater monitoring will be assessed by analyzing calibration check solutions. Accuracy control limits for the field measurements obtained during the field investigation activities are summarized in the field investigation SOPs in Appendix D.

1.2.2 Laboratory Accuracy Objectives

Laboratory accuracy will be assessed by determining percent recoveries from the analysis of matrix spikes or laboratory control samples (LCS). The accuracy of the organics analyses will be monitored through the analysis of surrogate compounds. Surrogate compounds are added to each sample, standard, blank, and QC sample prior to sample preparation and analysis. Surrogate compounds are not expected to be found occurring naturally in the samples, but behave analytically similar to the compounds of interest. Consequently, surrogate compound percent recoveries will provide information on the effect that the sample matrix exhibits on the accuracy of the analyses. Corrective measures, if needed, are described in the method SOPs (Appendix B).

1.3 Completeness

1.3.1 Field Completeness Objectives

Field completeness is a measure of the amount of valid field measurements obtained from all the measurements taken during the project. The equation for completeness is presented in the laboratory SOPs. The field completeness objective for this project will be 90 percent or greater.

1.3.2 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of valid laboratory measurements obtained from all the measurements taken during the project. The laboratory completeness objective for this project will be 95 percent or greater.

1.4 Representativeness

1.4.1 Measures To Ensure Representativeness of Field Data

Representativeness is dependent upon the proper design of the sampling program. Representativeness will be ensured by following the procedures described in this work plan and using proper sampling techniques.

1.4.2 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicate samples. The sampling network is designed to provide data representative of Site conditions.

1.5 Decision Rules

1.5.1 Decision Rule Objectives

If detectable concentrations of COPCs are detected in groundwater, the data will be screened using EPA's groundwater to indoor air VISL Calculator for residential and/or commercial/industrial scenarios. If detectable concentrations of COPCs are detected in soil vapor, the data will be compared to EPAs VISL for soil vapor to indoor air utilizing the EPA-recommended attenuation factors for residential and/or commercial/industrial scenarios. If COPC vapor concentrations exceed the screening levels, additional vapor monitoring will be conducted, including potential sub-slab and indoor air.

If the COPCs are detected in indoor air at concentrations above the action levels and corresponding outdoor ambient air results do not contain COPCs, then vapor mitigation may be required.

If COPCs are not detected in sub-slab vapors or indoor air (including crawl spaces) at concentrations above the action levels, then vapor mitigation will not be pursued.

1.6 Comparability

1.6.1 Measures to Ensure Comparability of Field Data

Comparability is dependent upon the proper design of the sampling program and will be ensured by using proper sampling techniques.

1.6.2 Measures to Ensure Comparability of Laboratory Data

The laboratory data to be obtained during the VI field investigation activities will be comparable to previous data when similar sampling and analytical methods are used. Comparability is also dependent on similar QA objectives.

1.7 Level of Quality Control Effort

Trip blank, equipment blank, field duplicate, matrix spike, method blank, and laboratory duplicate samples will be analyzed to assess the quality of the laboratory's data resulting from the field sampling and analysis program for the VI field investigation. Trip blank samples are used to assess the potential for contamination of samples resulting from contaminant migration during sample shipment and storage. Trip blank samples pertain only to aqueous VOC samples. Trip blank samples that consist of ultra-pure water are prepared in sample containers at the laboratory prior to the sampling event and are kept with the groundwater samples collected throughout the sampling event. Trip blank samples will be packaged for shipment with other groundwater samples and submitted to the laboratory for analysis. Trip blank sample containers will not be opened prior to analysis at the laboratory.

Method blank samples are generated within the laboratory and are used to assess contamination resulting from laboratory procedures. Field duplicate samples are analyzed to assess overall sampling and analytical reproducibility. Groundwater field duplicate samples are collected by alternately filling the sample containers for each parameter to be analyzed from the same sampling device. Vapor duplicate samples are collected by using a T-connector to join two vacuum canisters to one vapor source.

Matrix spikes provide information about the effect of the sample matrix on the preparation and measurement methodology. Matrix spike samples generally are analyzed in duplicate and are referred to as matrix spike/matrix spike duplicate (MS/MSD) samples. MS/MSD samples are investigative samples which have been fortified (spiked) by the laboratory with a known amount of the analyte(s) of interest. MS/MSD analysis is not applicable to air or vapor samples. Aqueous MS/MSD samples must be collected at triple the usual volume for VOCs.

The level of the QC effort for groundwater samples will be one equipment blank sample and one field duplicate sample for every 10 or fewer samples. One VOC trip blank sample consisting of laboratory-prepared ultra-pure water will be included along with each shipment of groundwater VOC samples. One MS/MSD sample will be submitted with every 20 or fewer samples collected for organic analyses.

The level of QC effort for field pH and conductivity measurements will include periodic calibration verification of the instrument using standard solutions of known pH and conductivity. Temperature measurements are obtained with pH and/or conductivity and field calibration is neither possible nor practical.

The level of QC effort for the vapor sampling program will be one field duplicate sample for every 20 or fewer vapor samples. Field duplicate samples will be collected by using a T-connector to split the sample into two canisters. Field blank and trip blank samples will not be collected because the canisters and flow controllers will be individually cleaned and certified by the laboratory prior to being shipped to the project location. In addition, pre-shipping and post-shipping vacuum measurements, post-sampling vacuum measurements in the field and at the laboratory, and the use of a tracer (sub-slab vapor sampling only) will indicate if sample integrity has been compromised during sampling or shipping. Consequently, field and trip blank sample data will not be required to evaluate sample integrity.

Table B.1

Targeted Reporting and Detection Limits
Vapor Intrusion Evaluation Work Plan
Wausau Water Supply Superfund Site
Wausau, Wisconsin

Chemical	Soil Probe and Sub-slab Targeted Reporting Limit (ug/m^3) [1]	Proposed Residential Sub-slab Action Level (ug/m^3)	Proposed Commercial/Industrial Sub-slab Action Level (ug/m^3)
Tetrachloroethene	5.4	360	1575
Trichloroethene	2.2	16	100
cis-1,2- Dichloroethene	3.2	NA	NA
Vinyl chloride	2	7.7	93
Carbon Tetrachloride	5	16	69
Chloroform	3.9	4.1	18

Chemical	Indoor Air / Ambient Air Targeted Method Detection Limit (ug/m^3) [1]	Proposed Indoor Air Residential Action Level (ug/m^3)	Proposed Indoor Air Commercial/Industrial Action Level (ug/m^3)
Tetrachloroethene	0.11	11	47
Trichloroethene	0.075	0.48	3.0
cis-1,2- Dichloroethene	0.10	NA	NA
Vinyl chloride	0.074	0.17	2.8
Carbon Tetrachloride	0.09	0.47	2.0
Chloroform	0.073	0.12	0.53

Note:

(1) - Targeted reporting and detection limits are presented for guidance and may not be achievable for all samples as a result of matrix interferences or high concentrations of target and non-target compounds.

Appendix C

Property Owner Introduction Letter Example and Access Agreement Letter Example

Example

January 31, 2023 Reference No. 003978

West Bank Access Letter
Name
Address
Wausau, Wisconsin

Dear Neighbor:

This letter is to inform you about the ongoing investigation of volatile organic compounds discovered in the groundwater near your neighborhood. This contamination is related to the Wausau Water Supply Superfund Site that has been the subject of investigations and cleanups since the 1980s.

These VOCs in the groundwater are chlorinated solvents, specifically trichloroethene (TCE) and similar compounds that occur due to the breakdown of TCE, such as cis-1,2-dichloroethene. TCE is a solvent used mainly to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. The TCE in the subsurface of this area is related to the former Wausau city landfill that is on the property currently owned by Regal Beloit (Marathon Electric) east of Cherry Street and south of Randolph Street.

Scientists have recently recognized that vapors from VOCs can be released from groundwater, move through soils and accumulate under buildings. Under certain conditions, these vapors can also move up through foundation floors and walls and enter the indoor air. This is called vapor intrusion and is very similar to the way in which radon gas – a naturally occurring element – enters some homes. Research conducted in the last several years tells us that the vapor intrusion pathway must be investigated beyond the boundaries of the property where the source was located.

Over the last 30 years the responsible parties have worked with the United States Environmental Protection Agency (EPA) and the Wisconsin Department of Natural Resources (DNR) to reduce concentrations of chlorinated VOCs in the groundwater. Soil and groundwater cleanup activities have been performed at the Marathon Electric property and concentrations in groundwater have been reduced significantly. However, remnants of contamination near the source area may still exist. Currently, groundwater contaminants originate on Marathon Electric property and flow underground to the north towards the City of Wausau's water supply well, CW6, which is near the intersection of Pearson Street and W. Crocker Street. The groundwater extracted by CW6 is pumped to the City's treatment plant where the contaminants are removed from the water.

In the coming days, you may see technicians testing groundwater and soil vapor in the neighborhood. These tests will help us determine whether TCE and related VOCs in the shallow groundwater is actually moving up through the soil as a vapor. We are coordinating with EPA and DNR to do this testing. This testing will also provide EPA and DNR with a more accurate picture of where and whether PCE vapors are a concern to the neighborhood. At this time we have no evidence that vapors related to VOC-impacted groundwater are present in any of the homes in your neighborhood.

We remain committed to the investigation and cleanup of the groundwater and will continue to share information as the work progresses. If you have any questions related to the science of vapor intrusion, EPA and DNR experts on vapor intrusion can be contacted at the numbers listed below. Please feel free to contact me if you have a question related to the field investigation or need an update on our progress.

Regards,

OJ Ojinaga
Engineer

+1 520 603-1923
oj.ojinaga@ghd.com

///

Encl. Fact Sheet: DNR PUB RR 892 What is Vapor Intrusion?
Vapor Intrusion Questions – WDNR - 715-839-3748

Example

January 31, 2023 Reference No. 003978

East Bank Access Letter
Name
Address
Wausau, Wisconsin

Dear _______:

Re: Request for Access for Sampling for Potential Vapor Intrusion

As part of the ongoing investigation of environmental contamination at the Wausau Water Supply Superfund Site, we are requesting permission to test your home or business for vapor intrusion. Vapor intrusion is the movement of vapors from chemicals in groundwater into the indoor air. It is very similar to the way that radon gas can move into a home or office. This testing is part of an ongoing investigation and cleanup of chlorinated volatile organic compounds (VOCs) being conducted by GHD at the direction of a group of Responsible Parties (RPs), including the Wausau Chemical Corporation (WCC), related to an accidental release of tetrachloroethene (PCE) at their facility on N. River Drive.

The results of the testing will tell us whether groundwater-related vapors are present in your home and they will also help us get a better idea as to whether vapors are a concern to the entire neighborhood.

Over the past 30 years we have worked with the DNR and EPA to reduce concentrations of chlorinated VOCs in the groundwater. Soil and groundwater cleanup activities have been performed at WCC and concentrations in groundwater have been reduced significantly. However, remnants of contamination near the source area may still exist. Currently, groundwater contaminants originate on the property owned by WCC. The contaminated groundwater flows underground to one of the City of Wausau's water supply wells, CW3, which is north of East Wausau Avenue and west of 3rd Street (west of the baseball field). The groundwater extracted from CW3 is pumped to the City's treatment plant where the contaminants are removed from the water.

As an agent of the RPs, GHD needs to collect an air sample from the soil beneath your foundation and from within your property to determine whether vapors from chemicals in the groundwater are present in your property and, if so, at what levels. This is part of the EPA/DNR-required investigation of the Wausau Water Supply Superfund Site and these air sampling tests will be paid for by the RPs.

In order to complete the site investigation, we will need to receive your signed access agreement (enclosed) by February 17, 2023. Please send a scanned PDF copy to me at oj.ojinaga@ghd.com. Lastly, please do not modify the access agreement in any way, as it may void the agreement.

Please give this request your prompt consideration. By taking action now to address potential chemical vapor intrusion in your property, you may avoid possible health and property liability issues in the future.

If you have questions or concerns about the wording of the agreement or any other aspect of this request, or the testing, please call me at (520) 603-1923.

Regards,

OJ Ojinaga
Engineer

+1 520 603-1923
oj.ojinaga@ghd.com

Encl. Fact Sheets and Access Agreement Form
Vapor Intrusion Questions – WDNR 715-839-3748

Consent for Access to Property

Property Owner's Name: ____

Property Address:____

____

OWNER Contact Information:

Owner's Mailing Address (if different from Property Address above):

____

Phone: _____________________________________ Email: _________________________________

The access permission is for the purpose of allowing GHD to screen the home/business for vapor intrusion of chlorinated volatile organic compounds located in soil/groundwater at the Wausau Chemical Corporation located near your property.

I consent to employees and authorized representatives of GHD Services Inc. (GHD) entering and having continued access to this property at reasonable times for the following purposes:

- Install and maintain sub-slab vapor probe(s) into the foundation (ground floor or basement) of the home or business.
- Conduct sub-slab soil vapor sampling from the sub-slab probes during February/March 2023.
- Conduct 24-hour indoor air sampling on the lowest regularly occupied level of the home or business (concurrent with sub-slab sampling) during February/March 2023.
- Abandon the vapor probe(s) when no longer needed.

I understand that GHD will provide a minimum of three days notice to the owner/occupant prior to conducting the sub-slab and indoor air sampling.

I realize that the sampling activities conducted by GHD are undertaken in accordance with a Work Plan, which was approved by EPA and the Wisconsin Department of Natural Resources (DNR).

The permission that is granted shall remain in effect until DATE when the vapor screening work is expected to be complete. If an extension is necessary to complete the work, GHD will inform you in writing.

The property owner agrees not to damage or interfere with the use of any sub-slab probe installed as permitted herein.

This written permission is given by me voluntarily, on behalf of myself and all other co-owners or lessees of these properties, with knowledge of the right to refuse and without threats or promises of any kind.

Property Owner

Signature:__________________________________Date:___________________________________

Tenant(s)/Lessee(s) by Unit Number, etc.

____

Name of Tenant(s)/Lessee(s)

____

Tenant(s) phone number

____

Tenant(s) email address

Please return to:

Please send a scanned PDF copy to me at oj.ojinaga@ghd.com. Lastly, please do not modify the access agreement in any way, as it may void the agreement.

Appendix D
Field Protocols and Field Sampling SOPs

Appendix D General Field Protocols

1.1 Decontamination Procedures

1.1.1 Drilling Equipment

Upon mobilization to the Site and prior to subsurface investigation activities, the DPT drill rig and equipment will be thoroughly cleaned to remove oil, grease, mud, and other foreign matter. Furthermore, all cutting bits, augers, probes, rods, samplers, drill steel, buckets, and associated equipment will be decontaminated prior to their use at subsequent testing locations.

Equipment decontamination will be accomplished by flushing and wiping the components to remove all visible sediments followed by:

1. High pressure washing with potable water to remove particulate matter and surface films
2. Rinsing thoroughly with potable water and Alconox™ or similar low-phosphate detergent. If necessary, a bermed and plastic-lined decontamination pad will be constructed for cleaning of the drilling rig and equipment. The decontamination pad will facilitate capture of cleaning fluids for proper management. Collected decontamination fluids will be managed as described in Section 2.1.4 below.

1.1.2 Sampling Equipment

Sampling equipment will be decontaminated before and after field utilization during the advancement of soil borings or the installation of temporary monitoring wells to prevent cross-contamination between locations. Whenever practicable, dedicated sampling equipment will be used to minimize the potential for sample cross-contamination.

Decontamination of equipment used for collection of samples for laboratory analyses will be performed as follows:

1. Wash with potable water and Alconox™, or similar low-phosphate detergent using a brush, as necessary, to remove all visible foreign matter
2. Rinse thoroughly with potable water
3. Rinse thoroughly with distilled water
4. Allow the equipment to air dry on a clean plastic sheet as long as possible. Following the final rinse, equipment will be visually inspected by GHD field personnel to verify that it is free of soil particulates and other solid material that could contribute to possible sample cross-contamination. Decontamination fluids will not be recycled between samples and will be managed as waste material as described in Section 2.1.4.

1.2 Field Documentation

A dedicated field logbook will be utilized for this project to detail the field activities conducted by GHD Services Inc. (GHD) during investigation activities. The field logbook will be a bound document with consecutively numbered pages. The entries for each day will commence on a new page, which will be dated and signed by the GHD field technician. All entries will be made only in indelible ink. Corrections will be made by marking through the error with a single line, to remain legible, and initialing this action followed by writing the correction.

The dedicated field logbook will be maintained by a GHD Site representative. Upon completion of the fieldwork or during periods when fieldwork is not scheduled, the field logbooks will be maintained in GHD's St. Paul, Minnesota office. Ultimately, after completion of all stages of fieldwork, the logbooks will be maintained in the permanent project file in GHD's St. Paul office.

The following information will be recorded in the field logbook or field data forms for each sample collected:

1. Site location identification
2. Unique sample identification number
3. Sample location
4. Date and time (in 2400-hour time format) of sample collection
5. Weather conditions
6. Designation as to the type of sample (groundwater, vapor, etc.)
7. Designation as to the means and methodologies for collection (grab, bailer, etc.)
8. Name of the sampler
9. Analyses to be performed on collected samples
10. Any other relevant comments such as odor, staining, texture, filtering, preservation, etc.

Records of equipment maintenance and calibration, and observations on equipment performance will also be recorded in the field logbook. Alternatively, GHD may utilize standard forms to record information such as records of equipment maintenance, stratigraphy, well construction, and well development.

1.3 Waste Handling

Investigation derived wastes (IDW) generated during the investigation will include general refuse, soil samples, decontamination fluids, and temporary well purging fluids. General refuse, including plastic sheeting, buckets, paper bags, etc., will be disposed of in waste receptacles. Daily refuse and personal protective equipment (PPE) will be collected in plastic bags and disposed of as necessary to keep the Site area clear of debris and refuse.

IDW generated during Site investigation activities will be placed into DOT approved 55-gallon drums and staged on Site at a location at the Site designated by the project management team. Decontamination fluids, purged groundwater, and sampling fluids will be purged directly into 55-gallon drums and staged at the designated location.

1.4 Utility Clearance

Prior to performing subsurface investigation activities, including the installation of soil borings or monitoring wells, GHD will contact the one-call system through the Wisconsin Digger’s Hotline (WDH) to locate and identify any subsurface utilities and obstructions. If necessary, a Site visit and review with applicable City engineering and utility offices may be warranted. If GHD requests WDH to locate public utilities and they are not located prior to performing drilling activities, GHD will immediately notify the WDH to obtain the locate status. If necessary, an emergency locate will be requested. No investigation activities will begin unless the public utilities have been properly marked. If private utilities are potentially present in the vicinity of the proposed investigation locations, GHD will subcontract a private utility locator to locate and mark the private subsurface utilities.

1.4.1 Sample Handling and Documentation Protocols

Sample Labeling

The samples will be labeled with a unique sample number that will facilitate tracking and cross-referencing of sample information. The sample identification system to be used is described as follows:

Example: GW-MMDDYY-XX-001

Where:

> GW - designates types of sample (GW-groundwater, SG-soil gas, SS-sub-slab, IA-indoor air, and AA-ambient air)
>
> YYMMDD - designates date of collection presented as year/month/day
>
> XX - designates sampler's initials
>
> 001 - designates sequential number starting with 001 at the start of the project

Field blank and field duplicate sample will also be identified with a unique sample number, consistent with the numbering system described above, to prevent laboratory bias of field QC samples.

1.4.2 Sample Containers and Handling

All samples will be placed in appropriate laboratory supplied sample containers, labeled, and properly sealed. Sample labels will include sample number, date of collection, and analyses to be performed. Groundwater samples will be carefully packed into shipping coolers by the use of bubble wrap or similar packing material and kept on ice while in GHD's custody. Samples will be shipped by commercial courier to the project laboratory. Samples collected on a Saturday, Sunday, or holiday will be stored on ice in coolers, sealed, and kept under surveillance by a GHD representative. Prior to shipment, the GHD representative will ensure that the samples have been stored appropriately and have not been tampered with.

Chain-of-custody seals will be placed on the front and back of each shipping cooler prior to shipment to secure the lid and provide evidence that the samples have not been tampered with during shipping. Clear tape will be placed over the seals to ensure that they are not accidentally broken during shipment. The GHD sampler will be responsible for packing, sealing, and delivering the sample coolers to an overnight courier. Upon receipt of the cooler at the laboratory, the cooler will be inspected by the laboratory sample custodian. The sample custodian will note the condition of the cooler and seal on the chain-of-custody form. The sample custodian will document the date and time the cooler is received and sign the chain-of-custody forms. The sample custodian will check the contents of the cooler with those samples listed on the chain-of-custody form. If damage or discrepancies are noticed, they will be recorded in the remarks column of the chain-of-custody form, dated and signed. Discrepancies will be reported to the laboratory supervisor who will inform the laboratory manager and quality assurance (QA) officer. Sample disposal will be the responsibility of the laboratory.

1.4.3 Chain-Of-Custody Forms

Chain-of-custody records will be used to track samples from the time of sampling to the arrival of samples at the laboratory. Each shipping container sent to the laboratory will contain an individual chain-of-custody form. The chain-of-custody form consists of four copies, which are distributed to the sampler, contract laboratory, and GHD's office files. The samplers will maintain their copies while the other three copies will be enclosed in a waterproof enclosure within the sample shipping container. Upon receipt of the samples, the laboratory will complete the remaining copies. The laboratory will maintain one copy for its records. The executed original will be returned to GHD with the data deliverables package.

1.5 Quality Control

A summary of the QA/QC samples scheduled for this project is provided on Table B.1 in Appendix B. Details regarding the media-specific QA/QC sampling protocols are provided in the sections below.

1.5.1 Groundwater Sampling

Groundwater QA/QC samples will include a field duplicate, equipment blank, trip blank, and matrix spike/matrix spike duplicate (MS/MSD). The QA/QC samples will be collected during groundwater sampling activities and analyzed to assess the quality of the data resulting from the field sampling program. Equipment and trip blanks will consist of analyte-free water and will be submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field-sampling program.

Equipment blank samples will be analyzed to document that decontamination procedures are not causing cross-contamination between samples. Equipment blank samples will consist of pouring distilled or deionized water over precleaned sampling equipment and into laboratory supplied sample containers. Trip blanks are used to assess the potential for contamination of VOC samples due to contaminant migration during sample shipment and storage. Field duplicate samples are analyzed to check for sampling and analytical precision. Matrix spikes provide information about the effect of the sample matrix on the preparation and measurement methodology. All matrix spikes are performed in duplicate.

The QC effort for this investigation will include the collection of one groundwater field duplicates and one equipment blank per 10 groundwater samples. One VOC trip blank sample consisting of water purged with an inert gas will be prepared by the laboratory and will be included along with each shipment of aqueous VOC samples. VOC trip blanks will be preserved by the laboratory in the same manner as the investigative samples. This investigation will also include the collection of MS/MSD samples. MS/MSD water samples will be collected at a frequency of one per 20 groundwater samples. MS/MSD samples will be collected at triple the volume for VOCs.

1.5.2 Vapor Probe/Sub-Slab/Indoor Air QC Samples

The QC effort for the proposed scope of vapor investigations will include the collection of one duplicate indoor air sample, and one duplicate sub-slab sample. Should additional vapor sampling events occur in the future, these samples will be collected on a 1 per 20 environmental samples.

The QA/QC samples will be collected using laboratory provided vacuum canisters and preset flow regulators. The purpose of collecting the ambient air sample is to screen out potential background contaminant sources during the collection of indoor air samples.

GHD Field Training Manual

Section 19.0
Indoor Air Sampling Standard Operating Procedures
Additional Text

(T120)

200010 (2) - Revision 0 - July 1, 2015

Please adhere to the following Quality System training requirements:

- Employees who are required to conduct a specific field activity must be properly certified to do the work.
- This involves reviewing the SOP and completing the online training course and exam.
- Employees must also conduct this field work under supervised conditions on at least three occasions, and must be certified by a qualified mentor. Only then can an employee conduct a specific field activity on their own. This is documented on a Field Method Training Record (QSF-021).
- Complete the QSF-021 and forward it to trainingrecords-northamerica@ghd.com.

Table of Contents

19. Indoor Air Sampling Standard Operating Procedures 1

19.1 Introduction 1

19.1.1 Prior Planning and Preparation 1
19.1.2 Safety and Health 1
19.1.3 Quality Assurance/Quality Control 2

19.2 Indoor Air Sampling Procedures 3

19.2.1 QA/QC Activities 3
19.2.2 Prior Planning and Preparation 3
19.2.3 General Field Procedures 4
19.2.4 Indoor Air Sampling Protocol 4
19.2.4.1 Physical Building Survey 5
19.2.4.2 Indoor Air Sample Collection Procedure 5
19.2.5 Field Instrumentation Calibration 8
19.2.6 Data Review and Validation 8

19.3 References 9

Forms Index

SP 27 Building Physical Survey Questionnaire

SP 28 Indoor Air Sampling Field Data Sheet

SP 29 Indoor Air Sampling Instructions to Building Occupants

Appendices

Appendix B Radiello® Indoor Air Sampling Protocols & Sampler Information

19. Indoor Air Sampling Standard Operating Procedures

19.1 Introduction

The procedures described herein pertain to the sampling of indoor air to evaluate the potential presence of volatile organic compounds (VOCs) in indoor air. VOCs can be present in a building's breathable air space from background sources such as glues, adhesives, construction materials, degreasers, cleaning products, aerosols, or organic vapor migration from beneath the structure (i.e., vapor intrusion) as a result of subsurface soil or groundwater impacts. The protocol presented herein consists of conducting a physical survey of the building in conjunction with interviewing building occupants, followed by collecting indoor air samples using Summa™ canisters and/or other applicable methods (i.e., passive samplers).

19.1.1 Prior Planning and Preparation

When designing and constructing the indoor air sampling program the following questions should be considered:

1. What is the purpose of the indoor air sampling?
2. What are the potential health and safety hazards?
3. What kinds of analyses are required (e.g., VOCs, petroleum hydrocarbon fractions)?
4. What type of building will be sampled (e.g., residential, commercial)?
5. What is the length of time over which the indoor air samples must be collected (e.g., 8 hours, 24 hours)?
6. Are there any potential background sources of the contaminants of concern?
7. Is the building occupied or vacant?
8. Has the HVAC system been in operation prior for 24 to 48 hours prior to the sampling event?
9. Where will the samples be collected from within the building?
10. Will the selected analytical method provide detection limits below the applicable screening levels?

> Note: If field staff are not aware of and able to answer all of the above noted questions before undertaking work in the field, the work plan must be reviewed in detail with the Project Coordinator/Manager.

19.1.2 Safety and Health

GHD is committed to conducting field activities with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP) Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a JSA to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

19.1.3 Quality Assurance/Quality Control

Quality assurance and quality control procedures should be implemented in every step of the assessment process to ensure the collection of data of acceptable quality. A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate an efficient site investigation.
- Allow for monitoring of staff and subcontractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 19.2.1.

19.2 Indoor Air Sampling Procedures

19.2.1 QA/QC Activities

The level of the QA/QC effort may include:

- A field duplicate.
- A trip blank (typically not required when using Summa canisters – however confirm with local regulatory guidance).
- Outdoor ambient (upwind - background).
- Laboratory certification (individual clean can or batch certification).

Consult appropriate regulatory agency guidance documents and the site-specific work plan for minimum required QA/QC. Applicable and current state and federal guidance for QA/QC indoor air sampling requirements take precedence over the protocols outlined herein. In general, the QA/QC protocols presented herein should be adhered to when state or federal guidance does not exist, or does not, specify QA/QC procedures, types, or frequencies. Field blank and field duplicate samples are analyzed to assess the quality of the data resulting from the field sampling program. A trip blank consisting of an unused Summa™ canister submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field sampling program. The trip blank sample will be analyzed to check for procedural contamination at the Site, which may cause sample contamination.

One field duplicate sample will be obtained for each day of sampling or from at least 10 percent of the samples obtained. The duplicate sample will be collected by using a splitter with separate sampling tubes connecting the splitter to two Summa™ canisters. Duplicate samples will be analyzed to check for sampling and analytical reproducibility. An extra Summa Canister should be considered in case of a faulty canister, gauge, or flow controller. The extra canister, if not needed, could be used as an additional duplicate sample.

An outdoor ambient air sample should be considered for QA/QC purposes to evaluate the potential presence and magnitude of constituent of concern concentrations present in background air in comparison to indoor air sampling results.

The level of QA/QC effort provided by the project laboratory for the samples analyses should correspond to the level of QA/QC effort specified in "The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis" (U.S. EPA, 1988).

19.2.2 Prior Planning and Preparation

The following will be considered prior to indoor air sampling:

1. Review the work program, project documents and the HASP requirements with the Project Coordinator/Project Manager.
2. Complete a Field Equipment Requisition Form (QSF-014). Assemble all equipment and supplies required.
3. Confirm the number of samples, their locations, and analyses with PM prior to completing a Simplified Scope of Work (SSOW).

4. For the laboratory analysis, contact the GHD chemistry group to coordinate:
    - QA/QC requirements.
    - SSOW (Simplified Scope of Work).
    - Laboratory selection (accreditation required).
    - Sample container delivery (be aware of hold-times).
    - Required sampling protocol, in addition to the protocol presented here.
    - Sample shipping details.
    - Duration of sampling (for time-weighted flow controllers).
5. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work QSF-031 for U.S. Work) is necessary for all Vendors who complete field services. Prior to mobilization, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
6. Discuss with property owner/manager the expectations for the sampling event. Ensure the property owner/manager notifies the tenant/employees of proposed sampling.
7. Weather conditions at the time of sampling. Changing weather conditions during the day indoor air samples were collected should be recorded in field logbook.

19.2.3 General Field Procedures

The following indoor air collection procedure outlines the procedure used by GHD in assessing the vapor intrusion pathway. The typical series of events that will take place are:

1. Sample location identification/inspection.
2. Indoor and outdoor air monitoring.
3. Field notes completion, review, checking.
4. Prepare samples for laboratory shipment.

Sample Location Identification/Inspection

Once at the site and prior to indoor air sampling, confirm that the sample location (i.e., indoor air location) has been correctly identified and located.

If it is necessary to relocate any proposed sample locations, the project coordinator must be notified and an alternate location will be selected and approved in the same manner. Most regulatory agencies require indoor air sample locations to be located within a central area of the room of the structure.

19.2.4 Indoor Air Sampling Protocol

The following sections describe the protocol for indoor air sampling. The first step of the procedure is the physical building survey as described in Section 19.2.4.1. The sampling procedure is described in Section 19.2.4.2.

19.2.4.1 Physical Building Survey

A physical survey will be conducted of the buildings to be sampled. The physical survey will be conducted in conjunction with interviewing the occupants and/or current owner of the buildings. It is highly recommended that the survey and interviews be conducted a minimum of 48 hours prior to sampling. The purpose of the physical survey is to obtain data that will allow a qualitative assessment of factors that potentially could influence indoor air quality. In addition, chemicals or products, which have the potential to affect the results of the indoor sampling, should be removed from the building to the extent feasible.

The physical survey includes collecting data on aspects of the building configuration/use(s) such as the following:

- Building layout.
- Foundation construction (e.g., slab-on-grade) and condition.
- Attached garages.
- Utility entrances into the building.
- Ventilation system design and operation.
- Presence of foundation sump.
- Building materials (e.g., recent carpeting/linoleum and/or painting).
- Location of laundry facilities, etc.

The physical survey should also include collecting data related to occupant lifestyle choices and/or work environment that could potentially influence indoor air quality such as the following:

- Storage or use of cleaning products, aerosol consumer products.
- Presence of recently dry-cleaned clothes or household items.
- Storage or use of solvents, paints, and/or petroleum hydrocarbon products.
- Smoking, etc.

The physical survey should be documented by completing the attached SP 27 – Building Physical Survey Questionnaire. It is recommended that a field drawing of the building be generated during the initial survey. Photographs should be collected to support the field drawing. For sampling at commercial and industrial properties, inquire property owner/manager if a Right-to-Know program exists for employees. Request copies of material safety data sheets (MSDS).

19.2.4.2 Indoor Air Sample Collection Procedure

Air samples will be collected from the buildings in the primary living and/or working areas of the building at locations considered representative of the breathing space. For buildings that are slab-on-grade construction, a minimum of 1 indoor air sample will be collected per floor of the building (e.g., a slab-on-grade house with two levels would have 2 samples collected – 1 from each floor). For buildings with a basement, a minimum of 1 indoor air sample will be collected from each level of the building including the basement. An outdoor ambient air sample should be collected contemporaneously with the indoor air sampling activities from an upwind location.

Summa™ Canister Method:

The indoor and outdoor ambient air samples will be collected using a Summa™ canister (6-litre capacity) equipped with a critical orifice flow-regulation device sized to allow the collection of an air sample over the selected time period (e.g., 24-hours). The critical orifice flow-regulation device must be supplied and calibrated by the laboratory selected to conduct the sample analysis.

To the extent possible, the indoor air samples should be collected with windows and building entry/exit doors closed. A closed (no circulation) condition should represent appropriately conservative (worst-case) conditions. If possible, windows and building entry/exit doors should be kept closed for a period of at least 24 hours prior to sample collection. Likewise, ingress and egress activities should be minimized. Heating, ventilation, and air conditioning (HVAC) systems should be operated normally for the season and time of day. During colder months, heating systems should be operating for at least 24 hours prior to the scheduled sampling event to maintain normal indoor temperatures above 65°F (18°C) before and during sampling. During summer months, air conditioners typically would be operating under closed windows/building entry/exit doors conditions, and the operation of an air conditioner can be allowed during sample collection. This would be representative of season-specific ventilation conditions, and within the expected parameters of operation of the building. Care should be taken to deploy the Summa™ canisters away from the direct influence of any blowing or forced air vents (e.g., those emanating from a window-style air conditioning unit or central air conditioning vents).

The indoor air sampling procedure is described as follows:

- Indoor air samples should be collected from an occupied area and as close as practical to the center of the area, but away from high traffic areas to minimize the potential for disturbances during sample collection. Typically, sample canisters should be located between 1 to 1.5 metres (m) or 3 to 4 feet above floor level for adults and at lower sampling heights if the predominant receptors are children, such as in a daycare center or school.
- For each outdoor ambient air sample, an upwind location should be selected. The outdoor ambient air sample should be collected a minimum of 1 m or 3 feet above grade and secured to minimize the potential for disturbance of the canister from weather effects.
- Air sample canisters should be labeled with a unique sample identification number. Both the sample number and the sample location information should be recorded in the project's field logbook. A bound field logbook and/or SP 28 – Indoor Air Sampling Field Data Sheet should be maintained to record all indoor air sampling data.
- A vacuum gauge must be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection. These pressures must be recorded in the field logbook. The vacuum gauge must be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory.
- The critical orifice flow controller must be installed, as supplied by the laboratory, on the canister and the canister must be opened fully at the beginning of sample collection period and start time. The start and finish times must be recorded in the bound field logbook.
- At the start and the end of the sampling period, a portable photoionization detector (PID) should be used to screen for VOC vapors in the sample area. Ideally, a low level, parts per billion (ppb), PID meter should be used during the building survey; and prior to, and during, the indoor

air sampling events. Results of the PID monitoring are to be recorded in the bound field logbook and SP 28 – Indoor Air Sampling Data Sheet.

- Equipment serial numbers, sampler name, calibration records, and any comments must also be recorded with the field logbook.
- Barometric pressure, outdoor ambient temperature, and interior temperature readings should be recorded at the start and completion of sampling. Data may be collected directly from field instrumentation or obtained via online sources (e.g., local NOAA weather station database).
- Following equipment setup, any building occupant(s) should be given the list of instructions to follow while the Summa™ canister sample is being collected in the building. The instructions are listed in SP 29 - Indoor Air Sampling Instructions to Building Occupants.
- The canister valve must be closed fully at the end of the sample period (e.g., after 24 hours) and the sample completion time recorded on the field data sheet. If there is evidence of canister disturbance during the sample collection, this should be recorded.
- The Summa™ canister vacuum must be measured immediately after canister retrieval at the end of the sample period and recorded on the field data sheet. Any sample where the canister reached atmospheric pressure (i.e., no vacuum), the sample should be considered for rejection and the canister returned for cleaning. The minimum residual vacuum required to be considered a valid sample may be dictated by regulatory guidance (generally at least 5-inches Hg vacuum). Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under standard chain of custody procedures. The requirement that a residual vacuum be retained in the canister following sample collection is to ensure that a driving force (pressure) and steady flow rate was maintained until the end of the sampling event.
- The indoor air samples collected via Summa Canister Method should be analyzed for VOCs by the project laboratory using U.S. EPA's TO-14, TO-15 SIM, or TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. As an additional QA/QC measure, the laboratory should perform a duplicate analysis of the sample collected in one of the canisters.

Passive Sampler Method:

There are several passive sampling devices that can be used to sample indoor air. The Radiello® diffusive samplers would be an example of a passive sampler that can be used. The following procedure is based the Radiello® diffusive samplers.

The samplers should be deployed at a height of approximately 5 feet above grade. In addition, one ambient air sample will be placed outside of the building. The ambient air sample should be collected using a 6-litre stainless steel evacuated canister (e.g., Summa® canister) over the selected time period (8-hour or 24-hour). The canister should be obtained certified clean from the laboratory and will be fitted with a laboratory calibrated flow controller to collect the ambient air sample over the selected time period). Sample collection should be terminated so that a residual vacuum can be maintained in the canister. The location of the ambient air sample should be upwind of the prevailing wind direction.

The Standard Operating Procedure (SOP) for sampling using the Radiello® diffusive samplers is presented in **Appendix B (**page A6).

The samples should be transported under standard chain-of-custody procedures to a certified laboratory for analysis. The Radiello® samplers should be analyzed by the project laboratory using EPA's Method TO-17 (EPA, 1999b). The ambient air sample should be analyzed by the project laboratory using EPA's Method TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology. All sample data should be validated.

QA/QC measures implemented during the program for the Radiello® samplers, and as specified in EPA Method TO-17 (EPA, 1999b), include collecting a field duplicate. No additional QA/QC measures will be taken for the ambient air sample.

> Note: The length of time for the ambient air sample using canister will very likely be different than the length of time that the passive sampler will be sampling the indoor air.

19.2.5 Field Instrumentation Calibration

Sampling or monitoring equipment used in the indoor and ambient air sampling program to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specification and requirements. A field calibration of the PID will be completed prior to sampling activities.

Any laboratory-supplied vacuum gauge(s) used to measure canister vacuum should be calibrated by the laboratory. The vacuum gauge should be returned to the laboratory, in order to allow the laboratory to obtain vacuum measurements prior to sample analysis (i.e., checking to ensure canister integrity was maintained during shipment).

The following activities will be performed at the completion of the field work.

1. The equipment should be cleaned and returned to the Equipment Coordinator. All equipment should be cleaned at the site.
2. Monitoring forms and field notes should be sent to the file. The field book should be stored at the appropriate GHD office.
3. Review and compare newly obtained data with historic data and note any unusual or extreme readings.

19.2.6 Data Review and Validation

Following receipt of analytical data, forward data to a GHD chemist for creation of tables, data validation review and reporting, and prepare electronic data deliverable (EDD) as needed. Compare analytical data to applicable indoor air quality standards. If no prescriptive numerical standards are available for your jurisdiction (e.g., New York), consider comparing the data to applicable U.S. EPA indoor air standards (e.g., Residential [10^{-4}] risk values). Note – indoor air concentration data are reported in units of micrograms per cubic meter ($\mu g/m^3$) and/or parts per billion by volume (ppbv). Unlike concentration units for groundwater, these units are not directly interchangeable. The molecular weight of the chemical compound is a factor in the conversion from units of mass per unit volume to parts per billion by volume. Ensure the laboratory reports the data in the units required by your guidance (New Jersey, for instance, requires that all data tables and EDD files report data in *only* $\mu g/m^3$).

Several states have Rapid Action Levels (RLs), which are more conservative than indoor air screening criteria. Typically, exceedance(s) of the RALs require immediate notifications to stakeholders (e.g., health department, state regulatory agency, property owner, and tenants). Consult your client following data review and prior to making any notifications. Exceedances of RALs often require immediate (e.g., within 2 weeks) mitigation remedies (e.g., SSDS installation, HVAC modification). Consideration should be given to performing an immediate confirmation sampling event.

19.3 References

Cal EPA, 2011. Final Guidance on the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance), Department of Toxic Substances Control, California Environmental Protection Agency, October.

Indiana Department of Environmental Management (IDEM), 2012. Remediation Closure Guide. March (with corrections to July 9, 2012).

MADEP, 2014. Draft Vapor Intrusion Guidance, WSC Policy #14-435, Executive Office of Energy & Environmental Affairs, Massachusetts Department of Environmental Protection, October.

USEPA, 1988. The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis.

USEPA, 1999a. USEPA Method TO-15.

USEPA, 199b. USEPA Method TO-17.

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

GHD Field Training Manual

Section 15.0
Soil Gas Sampling Standard Operating Procedures

(T113)

200010 (2) - Revision 1 – August 11, 2015

Please adhere to the following Quality System training requirements:

- Employees who are required to conduct a specific field activity must be properly certified to do the work.
- This involves reviewing the SOP and completing the online training course and exam.
- Employees must also conduct this field work under supervised conditions on at least three occasions, and must be certified by a qualified mentor. Only then can an employee conduct a specific field activity on their own. This is documented on a Field Method Training Record (QSF-021).
- Complete the QSF-021 and forward it to trainingrecords-northamerica@ghd.com.

Table of Contents

15. Soil Gas Sampling Standard Operating Procedures 1

15.1 Introduction 1

15.2 Prior Planning and Preparation 1

15.3 Safety and Health 2

15.4 Quality Assurance/Quality Control 2

15.5 Design Considerations 3

15.6 Soil Gas and Sub-Slab Probe Installation 4

15.6.1 Installation Procedures - Soil Gas Probes 4
15.6.2 Installation Procedures - Sub-Slab Soil Gas Probes 5
15.6.3 Installation Documentation 8
15.6.4 Follow-Up Activities 9

15.7 Soil Gas and Sub-Slab Sampling Protocol 9

15.7.1 Soil Gas Collection General List of Materials 10
15.7.2 Soil Gas Tracer Compounds 11
15.7.3 Soil Gas and Sub-Slab Probe Leak Testing 12
15.7.4 Sample Collection Procedure 14
15.7.5 Follow-Up Activities 17

15.8 References 17

Figure Index

Figure 15.1 Typical Soil Gas Probe Completion Detail

Figure 15.2 Typical Soil Gas Probe Completion Detail with Prefabricated Screen Implant

Figure 15.3 Typical Small Diameter Sub Slab Soil Gas Probe Completion Detail

Figure 15.4 Rotary Hammer Drilling Hole

Figure 15.5 Finished Hole from Rotary Hammer

Figure 15.6 Assembled Sub-Slab Probe

Figure 15.7 Preparing Assembled Sub-Slab Probe

Figure 15.8 Probe and Outside of the “Outer” Hole

Figure 15.9 Completed Installation of Sub-Slab Probe

Figure 15.10 Completed Installation of Sub-Slab Probe with a Tamper-Resistant Cap

Figure 15.11 Completed Installation of Sub-Slab Probe Plug

Figure 15.12 Typical Large Diameter Sub Slab Soil Gas Probe Completion Detail

Figure 15.13 Vapor Pin™ Assembly with Silicone Sleeve Over the Barbed End

Figure 15.14 Installing the Vapor Pin™

Figure 15.15 Flush-Mount Installation

Figure 15.16 Installed Vapor Pin™ with the Protective Cap

Figure 15.17 Typical Temporary Soil Gas Probe Completion Detail

Figure 15.18 Typical Soil Gas Sampling Assembly Schematic

Forms Index

SP-14 Stratigraphy Log Overburden
SP-15 Well Instrumentation Log

15. Soil Gas Sampling Standard Operating Procedures

15.1 Introduction

The procedures described in this section pertain to the installation of temporary and permanent soil gas and sub-slab probes to assess the vapor intrusion pathway. Soil gas and sub-slab probes are both used to collect soil gas samples; however, soil gas probes are installed at a greater depth, often outside a building, and sub-slab probes are installed to collect soil gas samples from immediately below a slab on grade or a basement floor slab. Permanent probes are recommended when more than one sampling event is required or when assessing seasonal variations in soil gas concentrations. Temporary probes are suitable for conducting a screening level assessment of vapor intrusion where the results could assist in locating future, permanent soil gas probes. Temporary probes are also suitable for conducting a preliminary evaluation of the magnitude and extent of volatile organic compound (VOC) impacts to the subsurface (e.g., such as in the case of a soil gas survey).

15.2 Prior Planning and Preparation

When designing and constructing soil gas and sub-slab probes the following questions should be considered:

1. What is the purpose of the soil gas probes?
2. What are the potential health and safety hazards?
3. What type(s) of soil gas probe construction materials are to be used?
4. What kinds of analyses are required (e.g., VOCs, petroleum hydrocarbon fractions)?
5. What are the geologic/hydrogeologic conditions at the site?
6. What are the seasonally high water table levels?
7. Do perched conditions exist at the site?
8. What is the anticipated total depth of the probes?
9. Are nested soil gas probes required for vertical delineations?
10. Does a vapor barrier already exist under the slab, if so, sub-slab sampling might puncture the barrier, so the hole must be carefully resealed after monitoring is complete?
11. If a basement exists, could the primary entry point(s) for vapor intrusion be through the sidewalls rather than from below the floor slab? If so, sub-slab samples might need to be augmented with samples through the basement walls.
12. Although sample collection and analysis are analogous to those in other types of soil gas sampling, is an analytical method with lower detection limits required since risk-based screening levels for sub-slab samples are lower than those for deeper soil gas samples?

> Note: If field staff are not aware of and able to answer all of the above noted questions before undertaking work in the field, the work plan must be reviewed in detail with the Project Coordinator/Manager.

15.3 Safety and Health

GHD is committed to conducting field activities with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP) Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

15.4 Quality Assurance/Quality Control

Quality assurance and quality control procedures should be implemented in every step of the assessment process to ensure the collection of data of acceptable quality. A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate an efficient site investigation.
- Allow for monitoring of staff and subcontractor performance.

- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis.

15.5 Design Considerations

Diameter

Soil Gas Probes

The probe casing diameter should be kept to a minimum to reduce the volume of soil gas that must be purged from the probe during sampling. A maximum casing diameter of 3/4-inch (19 mm) to 1-inch (25 mm) will be used for solid piping casing material (e.g., polyvinyl chloride [PVC]), although casing diameters this large are not recommended for deep soil gas probes (e.g., greater than 15 feet [4.6 m]) since large purge volumes (e.g., milliliters) will result. Casing diameters of 1/4 inch (6.4 mm) to 3/8-inch (9.5 mm) are typical when flexible tubing is used for the casing material (e.g., Teflon® or nylon).

Sub-Slab Probes

A typical sub-slab probe is constructed from small-diameter (e.g., 01/8- or 1/4-inch outside diameter) stainless steel or another inert material and stainless steel compression fittings. The probes are cut at a length to either float in the slab or to extend to the base of the slab.

Screened Interval and Sand Pack Material

Soil Gas Probes

The length and depth of the perforated (screened) section should consider the desired monitoring interval as well as the geologic conditions encountered. A typical screened section would consist of a 6-inch (0.15 m) to 1-foot (0.3 m) perforated section. The use of prefabricated stainless steel screen implants is common. Alternatively, the screened interval can be created from casing material by hand-cutting slots, or hand-drilling holes, into the casing at a regular pattern. For hand-cut or hand-drilled screened intervals, the preferred sand pack material for soil gas probes is pea gravel. For prefabricated screens, the preferred sand pack material is inert 10/20 silica sand (#1 morie sand) or glass beads.

Sub-Slab Probes

A screen is not always used with sub-slab probes. When a screen is utilized, it is often pre-fabricated with a length of approximately 6 inches, due to the limited depth intervals sampled. When a screen is not utilized, the bottom of the probe is left open to facilitate sample collection. The perforated or open section should be consistent with the desired monitoring interval and sub-slab conditions encountered.

Monitoring Parts

For both soil gas and sub-slab probes, airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves should be installed at ground surface to allow for an airtight connection to sampling equipment. The valve is required to isolate the soil gas sampling assembly from the soil gas probe while sampling assembly airtightness tests are conducted prior to probe purging and sampling.

Casing Materials

Soil Gas Probes

The materials selected for soil gas probe casing construction must be compatible with the volatile chemicals anticipated to be present in soil gas. Experience has shown that PVC casing is suitable when VOCs are present. However, as described above, PVC is typically not available in small enough diameters to provide practical soil gas probe purge volumes. To minimize purge volumes, small diameter (e.g., 1/4-inch [6.4 mm] to 3/8-inch [9.5 mm]) flexible tubing (e.g., Teflon® or nylon) is more commonly applied as the soil gas probe casing. Where solid casing is used (i.e., PVC), threaded piping will be used to avoid any possible contamination from solvent cement.

Sub-Slab Probes

The materials selected for sub-slab casing construction must be compatible with the volatile chemicals anticipated to be present in soil gas. Often, 1/4-inch OD stainless steel tubing is utilized to collect sub-slab soil gas. The length of the stainless steel (or brass) tubing is cut to a desired length prior to installation.

15.6 Soil Gas and Sub-Slab Probe Installation

The information contained in this section has been compiled from existing manuals, various reference documents, and a broad range of colleagues with considerable practical and educational backgrounds. This SOP outlines the generic procedures necessary to install a soil gas/sub-slab probe. Site conditions, contaminants and geology may require modification of this procedure. Review applicable government procedures and informational documentation prior to installation.

This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

15.6.1 Installation Procedures - Soil Gas Probes

The soil gas probe is to be installed using Geoprobe® dual tube sampling system to advance a borehole to the target depth. The dual-tube sampling system consists of first advancing a 2 1/2-inch (6.4 cm) diameter inner sampling probe followed by advancing a 3 1/2-inch (8.9 cm) diameter outer casing. The outer casing should cut away disturbed soil immediately surrounding the borehole left by the inner probe. The outer casing should create a zone of reduced soil disturbance due to the inner probe having already been advanced. It is anticipated that using the dual tube system will result in a minimum amount of soil disturbance around the borehole annulus. The soil lithology should be logged during drilling activities and recorded on a field boring log along with any applicable observations. Permanent soil vapor probes can be installed with a conventional drill rig equipped with a hollow-steam auger, although increased formation disturbances would likely result. Rotosonic and mud or air rotary drilling methods are not recommended since they can influence soil vapor sample results and/or alter the physical properties of the subsurface adjacent to the borehole annulus.

The probes should be constructed with a 6-inch (15 cm) to 12-inch (30 cm) long screened interval. The screened interval can be hand-fabricated or prefabricated. The probe casing should be constructed using flexible tubing or solid casing. Flexible tubing (e.g., Teflon® or nylon) of small diameter (e.g., 1/4-inch [6.4 mm] to 3/8-inch [9.5 mm]) is most commonly used in combination with prefabricated screened intervals. Solid casing (e.g., PVC) of small diameter (e.g., 3/4-inch [19 mm] to 1-inch [25 mm]) is most commonly used with hand-fabricated screened intervals. After positioning the screened interval and casing into the borehole, the screen should be surrounded by the appropriate sand pack material (i.e., pea gravel for hand-fabricated screens and 10/20 silica sand for prefabricated screens). When placing the sand pack into the borehole, 1 inch (2.5 cm) of sand pack material should be placed under the bottom of the probe screen to provide a firm footing. The sand pack should extend to 6 inches (15 cm) above the screened interval. A bentonite pellet seal should then be installed to 1-foot (0.3 m) above the sand pack and should be hand-hydrated. The remaining annulus should be backfilled with pre-hydrated bentonite cement. The soil gas probe casing should extend to ground surface and should be fitted with airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves to allow for an airtight connection to soil gas sampling equipment. A flush-mount protective cover should be installed above the soil probe and cemented into place. Schematics of typical soil gas probe installation details are presented on Figures 15.1 and 15.2, respectively, where hand-fabricated and prefabricated screened intervals are applied.

15.6.2 Installation Procedures - Sub-Slab Soil Gas Probes

Sub-slab soil gas probes allow for collection of soil gas samples from directly beneath the slab of a building. Sub-slab soil gas probes are not recommended when groundwater is present directly below the slab, since the slab could allow groundwater to enter the building. Sub-slab soil gas probes can be installed using several different methods: (1) utilizing a small diameter hole, (2) a larger diameter hole w/ flushmount casing and (3) a Vapor Pin™. Summaries of the steps involved are presented below:

Small Diameter Sub-Slab Soil Gas Probe:

A schematic of a typical small diameter sub-slab soil gas probe installation detail is presented on Figure 15.3.

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.
2. Prior to fabrication of the sub-slab vapor probes, use the rotary drill and the two inch diameter drill bit to create a shallow (e.g., 1/4 to 1/2 inch in depth) outer hole that partially penetrates the slab. This outer hole will allow the protective cap to be flush with the concrete surface (Figure 15.4).
3. Use a small portable vacuum cleaner to remove cuttings from the hole.
4. Use the rotary hammer drill and a one-inch drill bit to create a smaller diameter “inner” hole through the remainder of the slab to some depth (e.g., seven to eight centimeters or three inches) into the sub-slab material. Figure 15.5 illustrates the appearance of “inner” and “outer” holes. Drilling into the sub-slab material will create an open cavity, which will prevent the obstruction of any probes during sampling.
5. Use a small portable vacuum cleaner to remove cuttings from the hole.
6. Determine the thickness of the slab and record the measurement.

7. Assemble the vapor point using the basic design of a sub-slab vapor probe illustrated in Figure 15.3.

8. Place the assembled vapor point (Figure 15.6) into the hole and ensure the screen extends beyond the concrete and that the top of the probe is flush with the slab. Also apply the tamper resistant cap so as to not interfere with day-to-day use of the buildings. Cut tubing if necessary (Figure 15.7).

9. Confirm the fit of the rubber shaft plug to the sides of the boring. It should be snug with no gaps present. If additional thickness is necessary, plumbers putty can be added to the sides of the rubber.

10. Mix a quick-drying Portland cement to ensure a tight seal.

11. Inject the Portland cement with a 50 cc syringe or push into the annular space between the probe and outside of the “outer” hole (Figure 15.8).

12. Complete installed vapor point (Figure 15.9) with a tamper-resistant cap (Figure 15.10) or plug (Figure 15.11).

13. Allow cement to cure for at least 24 hours prior to sampling.

Sub-slab probes constructed in the aforementioned manner may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout. Inspect/clean the work area, and return site conditions to their original state.

If the tubing cannot be removed, the tubing should be cemented in place. All surface protective covers must be removed and returned to as close as possible to original site conditions.

Larger Diameter Hole w/ Flushmount Casing:

A schematic of a typical large diameter sub-slab soil gas probe installation detail is presented on Figure 15.12.

1. Prior to drilling holes into the building floor, the location of utilities coming into the building (e.g., gas, electrical, water, and sewer lines, etc.) must be identified. Avoid installing sub-slab soil gas probes near where utilities penetrate the slab as these may be entry points for downward ambient air migration through the slab during soil gas sampling.

2. A concrete corer is used to drill a hole through the concrete floor slab. The diameter of the hole should be sufficient to allow the installation of a protective casing within the hole. A sufficient space for placement of cement is required between the outer edge of the flush-mount casing and the hole in the concrete. Smaller diameter flush-mount protective casings are not recommended as they make accessing the probe within the casing difficult.

3. Once the hole in the concrete is cored and the center core removed, the flush-mount protective casing shroud should be cut to a suitable length. Ideally, the length of the shroud should allow the flush-mount casing to be flush with the surrounding floor while resting on the bedding material beneath the slab.

4. The probe assembly, including a valve at the top of the probe, should be placed so that the tip of the probe is within the bedding material beneath the concrete slab. Care should be taken to not force the probe into the bedding so that the open end of the probe doesn’t plug. Note: the probe assembly should be vacuum-tested on both sides of the valve prior to

installation. A piece of ¼ inch Teflon tubing should be attached at the top of the valve prior to installation. This tubing will allow easier access for the use of compression fittings to attach purging and sampling equipment to the probe.

5. The probe should be cemented into the flush-mount casing with hydraulic cement. The hydraulic cement should form a continuous seal from the bedding material to just below the top hex nut of the probe assembly.

Vapor Pin™

This SOP describes the procedure for installing a sub-slab soil probe using a Vapor Pin™. Borings should be done through the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified by the SOP (see below) and be of sufficient size to penetrate the expected thickness of the concrete present.

General List of Materials

This installation SOP utilizes the following products, which are available from Cox-Colvin & Associates, Inc. Equipment:

1. Silicone sleeve.
2. Hammer drill.
3. 5/8 inch diameter hammer bit (Hilti™ TEYX 5/8" x 22" #00206514 or equivalent).
4. 1½ inch diameter hammer bit (Hilti™ TEYX 1½" x 23" #00293032 or equivalent) for flush mount applications.
5. 3/4 inch diameter bottle brush.
6. Wet/dry vacuum with HEPA filter (optional).
7. Vapor Pin™ installation/extraction tool.
8. Dead blow hammer.
9. Vapor Pin™ flush mount cover, as necessary.
10. Vapor Pin™ protective cap.
11. Equipment needed for abandonment.
12. Vapor Pin™ installation/extraction tool.
13. Dead blow hammer.
14. Volatile organic compound-free hole patching material (hydraulic cement) and putty knife or trowel.

Flushmount Vapor Pin™ Installation Protocol

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.
2. Set up wet/dry vacuum to collect drill cuttings.
3. Drill a 1½ inch diameter hole at least 1¾ inches into the slab.

4. Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.
5. Drill a 5/8 inch diameter hole through the slab and at least six inches into the underlying soil to form a void.
6. Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.
7. Assemble the Vapor Pin™ assembly (Figure 15.13) by threading the Vapor Pin™ into the extraction/installation tool and placing the silicone sleeve over the barbed end.
8. Place the lower end of the Vapor Pin™ assembly into the drilled hole. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin™ to protect the barb fitting and cap, and tap the Vapor Pin™ into place using a dead blow hammer (Figure 15.14). Make sure the extraction/installation tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.
9. Unscrew the threaded coupling from the installation/extraction handle and use the hole in the end of the tool to assist with the installation (Figure 15.15). During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder.
10. Place the protective cap on the Vapor Pin™ (Figure 15.16).
11. Cover the Vapor Pin™ with a flushmount cover.
12. Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil gas conditions to equilibrate prior to sampling.
13. Remove protective cap and connect sample tubing to the barb fitting of the Vapor Pin™.

Temporary Soil Gas Probes

First, a core drill should be used to remove any surface cover, as needed. The temporary soil gas probes should consist of a decontaminated hollow sampling rod driven to the target depth below ground surface. The sampling rod should consist of a decontaminated 1-inch (2.5 cm) hollow stainless steel outer rod that is retracted to expose a 1-foot (0.3 m) long stainless steel screen. The rod should be advanced by a slide hammer to the target depth, and the outer rod retracted to expose the screen at the bottom of the rod. A surface seal comprised of hydrated bentonite cement should be placed around the base of the driven rod. The sampling rod should be completed at ground surface with airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves to allow for an airtight connection to soil gas sampling equipment. A schematic of a typical temporary soil gas probe installation detail is presented on Figure 15.17.

15.6.3 Installation Documentation

Details of each soil gas probe installation should be recorded on GHD's standard Stratigraphic Log Overburden (Form SP-14), or recorded within a standard GHD field book. The Well Instrumentation Log (Form SP-15) is provided for recording the overburden well instrumentation details, and can be used for soil gas probe installations. This figure must note:

- Borehole depth
- Probe perforation intervals
- Filter pack intervals

- Plug intervals
- Grout interval
- Surface cap detail
- Soil gas probe material
- Soil gas probe instrumentation (i.e., riser and screen length)
- Soil gas probe diameter
- Filter pack material
- Backfill material detail
- Stickup/flush-mount detail
- Date installed

The soil stratigraphy encountered at soil gas probes refusal must be recorded in accordance with GHD's standard borehole advancement methods (see Section 5.0).

Each soil gas probe should be accurately located on a site sketch. An accurate field tie to the center of the gas probe from three adjacent permanent features should be completed. The field ties should be located in a different direction from the installation.

Each soil gas probe must be permanently marked to identify the soil gas probe number designation.

15.6.4 Follow-Up Activities

Once the soil gas probe(s) have been completed, the following activities need to be done:

1. Conduct initial monitoring round of gas probes.
2. Submit all logs to the appropriate GHD hydrogeology department, who will be responsible for the generation of the final well log.
3. Survey accurate horizontal and vertical control of the soil gas borings and any pertinent structures needed to create a suitable site map.
4. Prepare an accurate soil gas probe/boring location map. Tabulate soil gas probe construction details.
5. Write-up all field activities including, but not necessarily limited to; drilling method(s), construction material, site geology.
6. Distribute all/any field book(s) to the appropriate GHD office.

15.7 Soil Gas and Sub-Slab Sampling Protocol

The following sampling protocols are for collecting a vapor sample through either a soil gas probe and/or sub-slab probe for the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (USEPA, 1999).

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. Considerations must be given to the types of chemicals of concern, lithology encountered, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

Most soil gas/sub-slab probes are installed at relatively shallow depths (less than ten feet below ground surface) so minimum purge volumes and low-volume samples must be performed to minimize potential breakthrough from the surface or between sampling intervals. Tracer/leak gas is necessary to ensure breakthrough does not occur and that a leak does not occur at any fitting above grade. Sampling should not occur during a significant rain event. A significant rain event is defined as 0.5 inches or greater of rainfall during a 24-hour period by Cal EPA (2012), or 1 centimeter or greater of rainfall during a 24-hour period by MOE (2013). A period of 1 day for coarse-grained soil conditions and several days for fine-grained soil conditions after a significant rain event should occur prior to collecting soil vapor samples. This time interval is required for drainage to occur and soil conditions to return to ambient moisture conditions.

Note: The sampling interval after a significant event should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

Samples from wells with multiple points installed must not be collected simultaneously and approximately 30 minutes must elapse between each sampled interval. Sample times should be documented on the field log. Sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize the potential for vacuum extraction of contaminants from the soil phase. A flow rate greater than 200 mL/min may be used when purging times are excessive, such as for deep wells with larger-diameter tubing. However, a vacuum of 100 inches of water (7.4 inches of mercury [Hg]) or less must be maintained during sampling whenever a higher flow rate is used. Volumes of various tubing sizes are provided in Table 1 in order to aid in calculating purge volumes.

Table 1 Volumes for Select Tubing Sizes

Tubing Size (inches ID)	Volume/ft (liters)
3/16	0.005
¼	0.010
½	0.039

Care must be used during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. Care must also be taken to avoid excessive purging prior to sample collection and prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. The sampling team must avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances) which could potentially cause sample interference in the field.

15.7.1 Soil Gas Collection General List of Materials

The equipment required for soil gas sample collection is as follows:

Flow Meters and Detectors

1. Flow regulator with vacuum gauge. Flow regulators provided by a qualified laboratory are pre-calibrated to a specified flow rate (e.g., 100 ml/min).
2. Photoionization detector (with appropriate lamp).
3. Helium detector (if helium is utilized as a tracer gas).
4. Methane meter for petroleum sites that is capable of also measuring percent of methane (CH4), carbon dioxide (CO2), and oxygen (O2).

Tooling and Supplies

1. Sampling canister (one per location).
2. Regulated flow meter assembly set to a maximum of 200 ml/min (one per location).
3. 1/4 inch tubing (Teflon®, polyethylene, or similar) and assorted fittings.
4. Plastic housing for using tracer gas.
5. 50 ml syringe (for purging).
6. Camera.
7. Adjustable crescent wrenches, small to medium size, and/or open end combo wrenches 9/16 to 1/2 inch.
8. Scissors/snips to cut tubing.
9. Ballpoint pens.
10. Nitrile gloves.
11. Compound to be used as tracer gas - lab grade helium or isopropyl alcohol (IPA).

15.7.2 Soil Gas Tracer Compounds

A leak in the sampling assembly may allow ambient air into the system and dilute the soil gas results (Benton and Shafer, 2007). Therefore, tracer gases must be utilized during the collection of soil gas samples to verify that the sample collected is from the installed sampling point. The presence of a tracer compound, whether liquid or gaseous, can confirm a leak in the sampling train assembly and whether the usability of the sample will need to undergo further evaluation.

Careful thought and consideration must be used when choosing a leak check compound as a tracer, since each compound can have specific benefits and drawbacks.

Helium used as a tracer gas beneath a shroud allows for the screening of the sampling train in the field. In conjunction with the use of a field meter capable of detecting helium, leaks within the sampling train could be detected prior to sampling. A retightening of all fittings prior to collecting the sample for analysis should be done. If a leak has been detected and is unable to be resolved, the sampling point may need to be decommissioned and a new one installed. Only lab-grade helium (UHP-Ultra High Purity) should be used as a tracer, since helium available at general merchandise stores may contain secondary contaminants, such as benzene.

Understanding the relationship between a leak and the concentration detected of the tracer gas used to check for leaks, the potential for absorption of the tracer gas (i.e., helium) onto sample train tubing, and the potential for interference by the tracer gas compound with VOCs is important in answering the data usability. An ambient air leak of up to five percent may be acceptable if quantitative tracer testing is performed. A soil gas vapor well should be decommissioned if the leak cannot be corrected. Any replacement vapor wells should be installed at least five feet from the location where the original vapor well was located

Note: The ambient air leak of up to five percent leak should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

15.7.3 Soil Gas and Sub-Slab Probe Leak Testing

The use of leak testing is recommended as a quality control check to ensure ambient air has not leaked into the soil gas probe or sampling assembly, which may affect (i.e., dilute) the analytical results. Contaminants in ambient air can also enter the sampling system and be detected in a sample from a non-contaminated sampling probe resulting in a "false positive" result. The leak testing should be conducted as described in the following two steps:

- Step 1 - Vacuum Test: used to ensure that the tubing and fittings/valves that make up the sampling assembly are air-tight
- Step 2 - Tracer Test: used to ensure that ambient air during soil gas sample collection is not drawn down the soil gas probe annulus through an incomplete seal between the formation and the soil gas probe casing.

The vacuum test and tracer test are detailed below.

Step 1 - Vacuum Test

- The sampling assembly must be connected to the soil gas probe valve at the surface casing. Once connected, the sampling assembly will consist of the soil gas probe, the vacuum gauge supplied by the laboratory, personal sampling pump, and Summa™ canister, all connected in series (i.e., in the order of soil gas probe, vacuum gauge, pump, and canister), using tee-connectors or tee-valves.
- The personal sampling pump will be used to conduct the vacuum test. The vacuum test should consist of opening the valve to the personal sampling pump while leaving closed the valves to the Summa™ canister and the soil gas probe. The pump should then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.
- If the pump is capable of drawing flow, or if the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.
- The reading from the vacuum gauge pressure should be recorded in field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly (it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for at least 1 minute.

Step 2 - Tracer Test

A tracer compound is released at ground surface immediately around the soil gas probe surface casing and is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. Two options are described below for the tracer test where either isopropanol (Option A) or helium (Option B) is used as the tracer compound.

Option A - Isopropanol

- For Option A, isopropanol is used as the tracer compound. It is included as an analyte in U.S. EPA's TO-15 method, it is readily available (i.e., as isopropyl rubbing alcohol), and it is safe to use.
- Approximately 1 teaspoon (approximately 4 mL) of isopropanol (rubbing alcohol) should be mixed in 1 gallon of de-ionized water to create an approximate 1/1,000 solution.
- Paper towels soaked in a dilute solution of isopropanol should then be wrapped around the soil gas probe surface casing and ground surface immediately surrounding the surface casing. Soil gas probe surface casing then should be covered over, using clear plastic sheeting that will be sealed to the ground surface. As the ground surface finish permits, sealing the plastic sheeting to ground surface should be accomplished by using tape or by weighting the edges of the plastic sheeting with dry bentonite.
- Immediately before conducting the soil gas probe purging, remove the paper towels from the solution, wringing out the towels so they are very damp, but not dripping. Place them around the vapor probe and seal them in place using the plastic sheeting.
- The isopropanol solution should be kept fresh, with new solution being made every hour. The solution should be mixed at a central location away from the sampling activities. The isopropanol should be kept tightly capped and kept away from all sampling equipment. The solution should be kept away from the sampling assembly until immediately before sample collection begins. Sampling personnel must wear latex gloves while handling the solution and soaked paper towels, and will remove the gloves while working with the sampling assembly.
- Soil samples with laboratory analytical results for isopropanol that are greater than 10 percent of the starting concentration of isopropanol in the vapors emitted from dilute isopropanol solution should not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007). The starting concentration should be calculated based on the concentration of isopropanol in the dilute solution, the vapor pressure of isopropanol, and Henry's law.
- A disadvantage in using isopropanol as the tracer compound is that it will not be known whether a significant leak occurred until after the cost of analyzing the sample has been spent. Elevated levels of isopropanol can also interfere with laboratory analytical method detection limits.

Option B - Helium

- The presence of helium within the sampling assembly should be monitored during purging and soil gas sample collection using a helium meter installed in-line with the sampling assembly. The meter should be positioned along the sampling line just before the personal sampling pump.
- Helium is readily available at a variety of retail businesses, is safe to use, and does not interfere with laboratory analytical method detection limits.

- A containment unit is constructed to cover the soil gas probe surface casing. The containment unit should consist of an overturned plastic pail set into a ring of dry bentonite to create a seal between the ground surface and the rim of the pail. The pail can be set directly on top of the sampling assembly tubing connected to the soil gas probe, which when pressed into the dry bentonite, should create a sufficient seal around the tubing. The pail will have two holes: one to allow for the introduction of helium; and the other to allow for air trapped inside the pail to escape while introducing the helium. The second hole will also allow insertion of the helium meter to measure the helium content within the pail.
- Prior to soil gas probe purging, helium will be introduced into the containment unit to obtain a minimum 50 percent helium content level. The helium content within the containment unit should be confirmed using the helium meter and recorded in the field logbook. Helium should continue to be introduced to the containment unit during soil gas probe purging and sampling and care should be taken not to increase the pressure within the containment unit beyond that of atmospheric pressure.
- During soil gas probe purging and sampling, the helium meter should be connected in-line with the sampling assembly. In the event that the helium meter measures a helium content with the sampling assembly of greater than 10 percent of the source concentration (i.e., 10 percent of the helium content measured within the containment unit), the soil gas probe will be judged to permit significant leakage such that the collected soil gas sample will not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007).
- An advantage of using helium as the tracer compound is that a significant leak can be detected in the field and the cost of analyzing the Summa™ canister can be avoided.

Note: The 10 percent of the source concentration should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

15.7.4 Sample Collection Procedure

1. Soil gas samples for assessing the vapor intrusion pathway must be collected using an acceptable canister, including certified clean Summa™ canisters. Only canisters certified clean at the 100 percent level can be used for soil gas sampling activities (i.e., pre-cleaned at the laboratory in accordance with U.S. EPA's TO-15 method and documentation of the cleaning activities will be provided by the laboratory). Summa™ canisters typically come in 1-, 1.7-, and 6-liter capacities, depending upon laboratory availability.
2. The canisters must be fitted with a laboratory-calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum soil gas sampling flow rate recommended by Cal EPA (2012) of 100 to 200 mL/min. The 100 mL/min maximum flow rate is equivalent to sample collection times of 10, 17, or 60 minutes, respectively, for of 1, 1.7, or 6 liter canister capacities. A maximum flow rate of 100 mL/min is recommended to limit VOC stripping from soil, prevent the short-circuiting of ambient air from ground surface down the soil gas probe annulus that would dilute the soil gas sample. A maximum flow rate of 100 mL/min increases confidence that the soil gas sample is drawn from immediately surrounding the screened interval.
3. A vacuum gauge should be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual

canister vacuum at the end of sample collection. The vacuum gauge will be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory.

4. The canister should be connected to the soil gas probe valve at the surface casing using the sampling assembly (see Figure 15.18). The sampling assembly is connected using short lengths (e.g., 1-foot [0.3 m]) 1/4-inch (6.4 mm) or 3/8-inch (9.5 mm) diameter tubing (the tubing material will be Teflon® or nylon) and airtight stainless steel or brass tee-connectors and tee-valves (e.g., Swagelok® type). The canister should be connected to the soil gas probe along with a vacuum gauge and a personal sampling pump, all in series, using tee-connectors or tee-valves (in the order of soil gas probe, vacuum gauge, pump, and canister). A tee-valve should be used to connect the pump, which will allow the pump to be isolated from the sampling assembly during sample collection. Fresh tubing must be used for each sample.

5. Prior to collecting a soil gas sample, the stagnant air in the sampling assembly tubes and soil gas probe casing/sand pack must be removed. The soil gas probes should be purged prior to sampling using the personal sampling pump at a flow rate of less than 200 mL/min. A flow rate greater than 200 mL/min may be used when purging times are excessive, such as for deep wells with larger-diameter tubing. However, a vacuum of 100 inches of water (7.4 inches of Hg) or less must be maintained during sampling whenever a higher flow rate is used. This ensures that the collected soil gas sample is representative of actual soil gas concentrations within the formation. Measurements of the lengths and inner diameters of the above-ground sampling assembly and below-ground gas probe casing, screen, and sand pack should be used to calculate the "purge volume" (the purge volume will consider the pore volume of the sand pack assuming a 30 percent sand pack porosity). Prior to sample collection, two to three purge volumes should be drawn from the probe/sample assembly, unless otherwise required by the applicable regulatory guidance. The purge data (calculated purge volume, purging rate, and duration of purging) should be recorded in the field logbook.

6. Prior to purging, a vacuum, or tightness, test should be conducted on the sampling assembly as the first of two leak-testing steps, as described further in Section 15.7.3. Briefly, this first leak-testing step (the vacuum test) should consist of opening the valve to the personal sampling pump leaving the valves to the Summa™ canister and the soil gas probe closed. The pump should then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are airtight. Further details of the vacuum test are described in Section 15.7.3.

7. Prior to purging, and following the vacuum test, the set-up for the second of the two leak-testing steps should be conducted. The second leak-testing step is the tracer compound step. A tracer compound is released at ground surface immediately around the soil gas probe surface casing. The tracer test is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. The tracer compound is either monitored using a meter connected in-line to the sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the soil gas samples (e.g., isopropanol). The setup requirements of the tracer compound leak-testing step are described in Section 15.7.3.

8. Following the vacuum test, and the setup for the tracer compound leak-testing step, the soil gas probe purging should commence by opening the valve to the soil gas probe and activating the personal sampling pump (and leaving closed the valve to the Summa™

canister). At the start and the end of the purging period, the total concentration of volatile organic vapors of the personnel sampling pump exhaust gas should be monitored using a portable photoionization detector (PID) meter. The PID meter should be connected in series after the personal sampling pump. Since typical PID instrument flow rates vary from approximately 300 to 500 mL/min (depending on the manufacturer and model), drawing a sample into the PID meter through the personal sampling pump will likely increase the purging flow rate temporarily, until a reading from the PID meter is obtained. PID readings should be recorded and entered in the field logbook and chain of custody form. The PID readings should provide the laboratory with an indication of whether a sample could require dilution before analysis.

9. Following purging, the valve to the personal sampling pump should be closed, and the valves to the soil gas probe and Summa™ canister opened to draw the soil gas sample into the canister. This should be completed concurrent with continued application of the leak-testing tracer compound. The vacuum gauge reading must be recorded during sample collection. Should the vacuum gauge reading remain elevated above 10 inches Hg for more than 30 minutes, this will be taken to indicate that the initial vacuum in the canister has not sufficiently dissipated, and that the soil screened by the soil gas probe does not produce sufficient soil gas to permit sample collection due to low permeability soil. If low permeability conditions are encountered, the probe can be sampled using the techniques outlined in Appendix D (Soil Gas Sampling in Low Permeability Soil) of Cal EPA (2012).

10. To ensure some residual vacuum in each canister following sample collection, the canister vacuum should be recorded at approximately 80 percent through the expected sample collection duration. With a 100 mL/min maximum flow rate, the expected sample collection duration would be 10, 17, or 60 minutes, respectively, for canister capacities of 1, 1.7, or 6 liters. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until vacuum reading is below this threshold, unless the vacuum remains above 10-inches Hg for more than 30 minutes, as described above. A minimum 0.5 to 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap must be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under chain-of-custody procedures.

Note: The 0.5 to 1-inch Hg residual vacuum should be verified based on the applicable jurisdictional regulatory vapor intrusion guidance.

11. The vacuum gauge provided by laboratory must be returned with the canister samples to check residual vacuum in the laboratory prior to sample analysis and recorded on the analytical data report. This check will ensure sample integrity prior to laboratory analysis, and that the canister has not become compromised during shipment to the laboratory.

12. If the critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves are to be re-used during sampling, they must be cleaned in accordance with laboratory requirements by purging with zero air (provided by laboratory) for minimum 45 seconds at minimum 75 psi (153 inches of Hg).

13. The canisters should be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook should be maintained to record all soil gas sampling data.

14. The canisters should be listed on the chain-of-custody in order of suspected highest to lowest impact, as evidenced by the recorded PID readings. Indicate on the chain-of-custody for the laboratory to analyze the canisters in order from the lowest to highest PID reading.

The soil gas samples should be analyzed for VOCs by the project laboratory using U.S. EPA's TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. QA/QC measures implemented during the soil gas sampling event will include the two-step leak testing procedure (see Section 15.7.3), maintaining a minimum residual vacuum in the Summa™ canisters following sample collection, collection of one duplicate per sampling event or from at least 10 percent of the samples obtained, and collection of an ambient air sample (if needed). As an additional QA/QC measure, the laboratory should conduct a duplicate analysis of the sample collected in one of the canisters.

15.7.5 Follow-Up Activities

The following activities should be performed at the completion of the field work.

1. Review and compare newly obtained data with historic data and flag unusual or extreme readings for review.
2. Soil gas concentrations are reported in units of µg/m^3 or ppbv. Unlike concentration units for groundwater, these units are not directly interchangeable. The molecular weight of the compound in question is a factor in the conversion from units of mass per unit volume to parts per billion by volume.
3. Ensure site access keys are returned.
4. The equipment should be cleaned and returned to the Equipment Coordinator. All equipment should be cleaned at the site.
5. Monitoring forms and field notes should be sent to the file. The field book should be stored at the appropriate GHD office.

15.8 References

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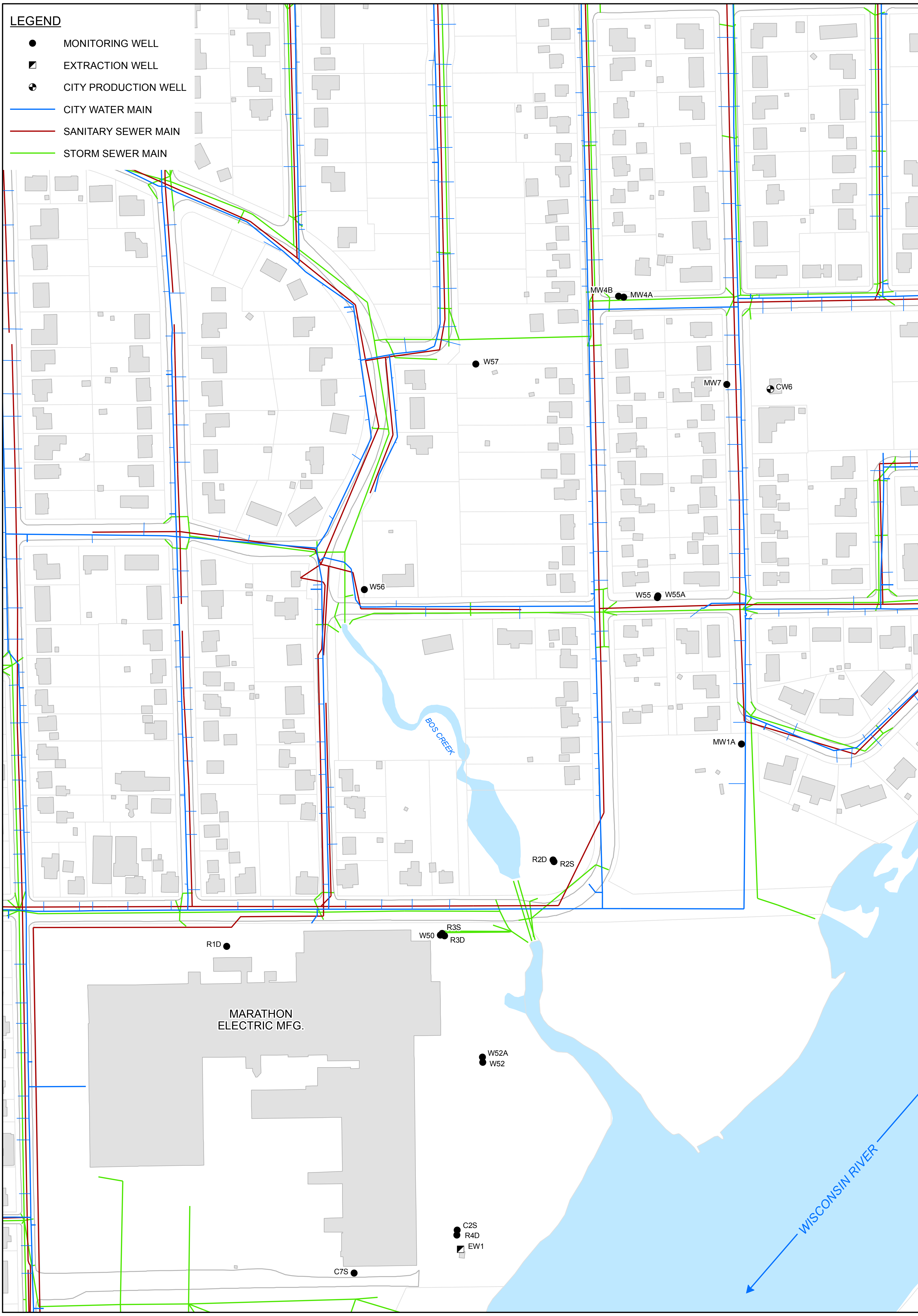
USEPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples. EPA/600/R-05/147, March.

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

Appendix E

Sewer and Water Utility Maps



Source: Marathon County

0 100 200 ft

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN
VAPOR INTRUSION EVALUATION WORK PLAN

WEST BANK UTILITIES

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Feb 17, 2017

APPENDIX D

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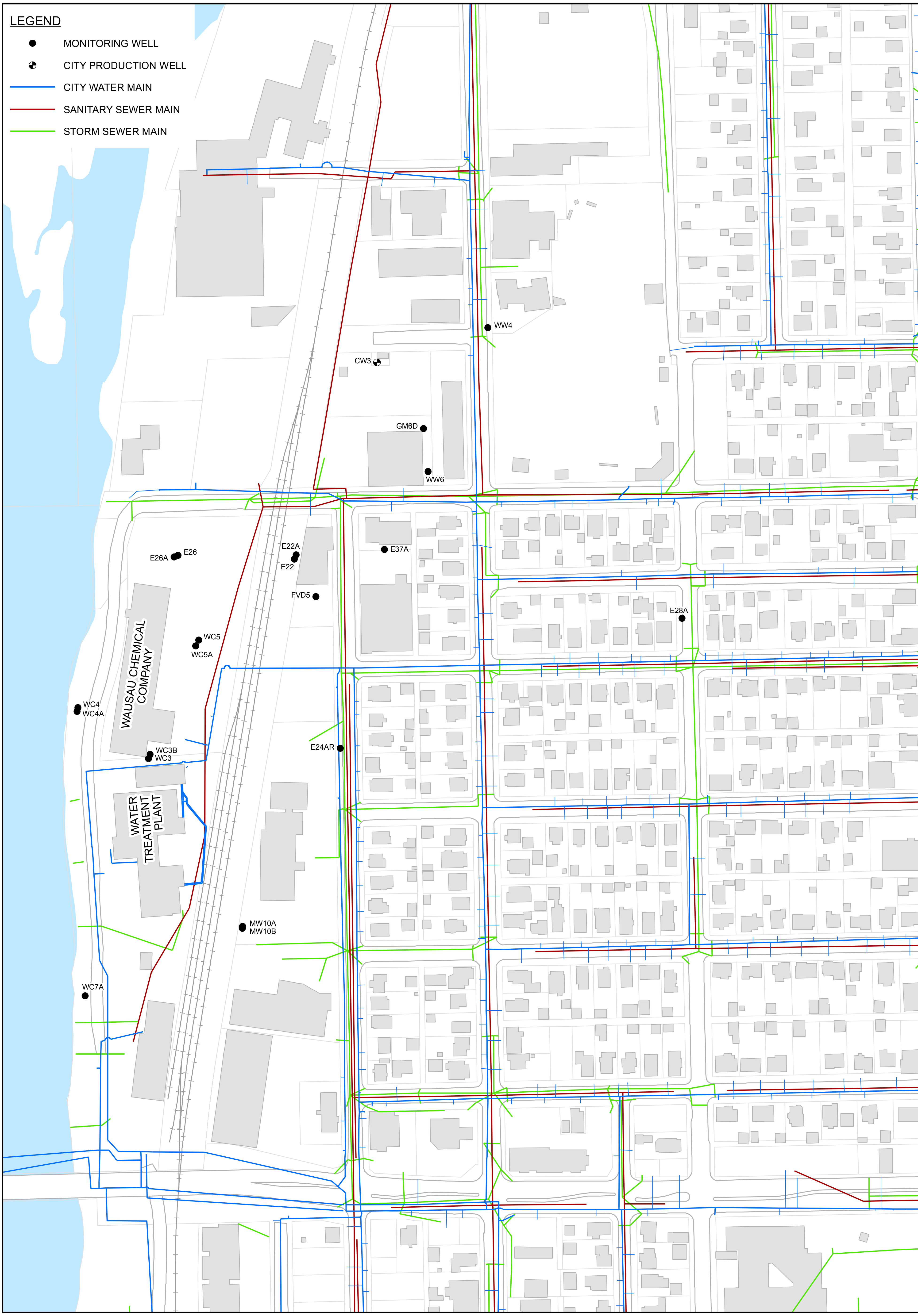

Source: Marathon County

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WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN
VAPOR INTRUSION EVALUATION WORK PLAN

EAST BANK UTILITIES

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