Memo

SUBJECT
2025 Joslyn Groundwater Sampling Summary

TO
Emily Bertolini, EGLE

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DEPARTMENT
Environment

PROJECT NUMBER
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Arcadis of Michigan, LLC (Arcadis) has prepared this memorandum (memo) on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust. Groundwater sampling activities were conducted by Arcadis at a vacant 0.455-acre parcel (Parcel ID 14-21-205-001) currently owned by RACER Properties LLC and located in the vicinity of the RACER Pontiac North Site in Pontiac, Michigan. The parcel (herein referred to as the Joslyn South Parcel or "Site") is bounded to the west by Joslyn Avenue, north by Wesbrook Street, south by Lenox Avenue, and east by residential properties. This memo describes the groundwater monitoring conducted during the 2025 calendar year. The location and Site layout is shown in **Figures 1** and **2**, respectively.

The *2024 Joslyn South Parcel Groundwater Sampling Summary Report*, dated December 27, 2024, provided a comprehensive summary and evaluation of groundwater monitoring for the Site. Based on that evaluation, sampling of the three monitoring well locations along the eastern property boundary (JS-MW-06, JS-MW-16, and JS-MW-19), and closest to residential properties was recommended. Please refer to the 2024 report for more information. Monitoring was completed at those three monitoring wells on September 10th and December 11th, 2025. Monitoring activities included gauging the three monitoring well locations, followed by groundwater sample collection for volatile organic compound (VOC) laboratory analysis.

Groundwater monitoring, laboratory analytical results, and analytical trends are summarized in the following sections.

Groundwater Sampling Activities

Prior to groundwater sampling, each of the three monitoring wells were gauged to the nearest 0.01 foot with an electronic water level meter. Refer to **Attachment 1** for the groundwater sampling logs and water levels recorded prior to sampling at the three wells. Groundwater samples were collected from monitoring wells using low-flow sampling procedures (USEPA 2017), which is the United States Environmental Protection Agency (USEPA) Region V and Michigan Department of Environment, Great Lakes and Energy (EGLE) standard method for collecting low-stress/low-flow groundwater samples from monitoring wells. All groundwater samples were collected in accordance with the Arcadis Technical Guidance Information (TGI) for low-flow groundwater purging and sampling procedures for monitoring wells (**Attachment 2**).

During sampling, purge water was monitored for dissolved oxygen (DO), temperature, specific conductivity, turbidity, oxygen reduction potential (ORP), and pH. These water quality measurements were used to determine groundwater sample stability prior to collection of the groundwater samples. All groundwater sampling logs are provided in **Attachment 1**.

Groundwater samples were collected and submitted to Merit Laboratories, Inc. (Merit) in Lansing, Michigan for analysis of VOCs using USEPA Method 8260C.

Groundwater Analytical Results

Monitoring wells sampled in 2025 included JS-MW-06, JS-MW-16, and JS-MW-19. These monitoring wells are located along the eastern property boundary and used to evaluate the potential for vapor intrusion (VI) at the residential property located east of the Site. Groundwater samples plus quality assurance quality control samples (QAQC) were collected and analyzed for VOCs from the three monitoring wells on September 10, 2025 and well JS-MW-16 was resampled on December 11, 2025.

Groundwater data collected were compared to Site-Specific Volatilization to Indoor Air Criteria (SSVIAC) obtained from the Michigan Department of Environment, Great Lakes and Energy (April 2022) and EGLE Part 201 Clean-up Criteria (October 2023). The SSVIAC utilized for comparison included residential criteria for basement scenario and nonresidential criteria for slab-on-grade building less than 50,000 square feet scenario. A summary of the groundwater analytical results compared to criteria for the three monitoring wells sampled is provided as **Table 1** and **Figure 2**. The laboratory analytical reports are provided as **Attachment 3**. Trend graphs and Mann-Kendall trend analyses are provided in **Attachment 4** and discussed further in the section below.

Based on the 2025 groundwater analytical results the following was observed:

- The sample from monitoring well JS-MW-16 collected during the September sampling event exceeded the Residential Drinking Water Criteria (RDWC), Nonresidential Drinking Water Criteria (NRDWC), and Residential SSVIAC for benzene and the Residential and Nonresidential SSVIAC for 1,2-dichloroethane (1,2-DCA) and isopropyl benzene.
    - Based on the results of September sampling event, JS-MW-16 was sampled again on December 11, 2025. The results of the December sampling event showed an exceedance of the RDWC, NRDWC, Residential SSVIAC, and Nonresidential SSVIAC for 1,2-DCA, and the Residential SSVIAC for benzene.
    - Other compounds that were detected in JS-MW-16 during the December 2025 sampling event but did not exceed criteria include 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, N-propyl benzene, and xylene.
- Samples collected from JS-MW-06 and JS-MW-19 during the September 2025 event were non-detect for all VOC compounds analyzed and therefore no samples were collected from these wells in December.

Groundwater Analytical Trends

Mann-Kendall analysis was completed for monitoring well JS-MW-06 for ethylbenzene; JS-MW-16 for 1,2-DCA, and benzene; and JS-MW-19 for benzene (**Attachment 4**). The Mann-Kendall statistical trends are summarized on **Figure 3**. For monitoring wells that did not meet Mann-Kendall criteria but had a detection since 2023, a trend graph has been created and included in **Attachment 4**. Trend graphs are included for benzene and 1,2,4-trimethylbenzene for JS-MW-06, and isopropyl benzene and 1,2,4-trimethylbenzene for JS-MW-16. The criteria used for the Mann-Kendall analysis follows:

- At least 5 sampling results.
- At least 50% of concentrations are detected measurements.

Key findings of the trend analysis are summarized below:

- Concentrations of ethylbenzene at JS-MW-06 show a decreasing trend.
- Concentrations of 1,2-DCA and benzene at JS-MW-16 show no significant trend.
- Concentration of benzene at JS-MW-19 show a decreasing trend.

In summary, concentration of key constituents at JW-MW-06, JS-MW-16 and JS-MW-19 have shown variability but have a statistically decreasing or no significant trend.

Recommendations

Based on the results of the 2025 monitoring, it is recommended that a soil vapor monitoring point (SVMP) be installed east of JS-MW-16 near the property boundary and groundwater monitoring continue at the property boundary. The location of the proposed SVMP is shown on **Figure 4**. The scope of work for the SVMP installation and soil vapor and groundwater sampling is detailed below:

- At one location, install a SVMP targeting the depth of a standard residential basement (approximately 10 feet below ground surface [bgs]). The water table will be confirmed prior to installation of the SVMP and the SVMP will be installed 1-foot above the water table. The soil boring for the SVMP will be logged in accordance with the Arcadis Soil Description Technical Guidance Information (TGI) provided as **Attachment 2**. Installation of the SVMP will be completed in accordance with the Arcadis Installation of Soil Vapor Probes TGI (**Attachment 2**). The SVMP will be constructed of a ½" OD 6" stainless steel screen attached to ¼" outer diameter nylon lined tubing that extends to the ground surface. Filter sand material will be installed from the base of the screen to 6" above its top. Dry granular bentonite will be installed 6" above the filter sand. Hydrated bentonite will be installed from the top of the dry bentonite to within 6" of ground surface. The SVMP will be protected by a 5" steel flush-mount well cover set in a concrete pad at the ground surface.
- A soil vapor sample will be collected from the newly installed location one week after installation, and then quarterly for three additional consecutive quarters.
- All soil vapor sampling will be completed in accordance with the Arcadis Sub-Slab and Soil Vapor Sampling Using Whole Air Canisters TGI (**Attachment 2**). In summary, the methodology for collecting soil vapor samples will include a helium leak test to verify the seal of the sampling point, and a "shut-in" test completed on the sampling train to verify that a closed system is in place prior to sampling. Following a passed helium leak test and shut-in test, a SUMMA® canister, with attached pre-set flow regulator, will be used to collect the sample for laboratory analysis of VOCs in accordance with the USEPA Method TO-15. The laboratory for completing the analyses will be Eurofins Air Toxics, LLC/TestAmerica and the standard operating procedure for the TO-15 method is included in **Attachment 5**. Following sampling, an additional three volumes of air will be purged into a Tedlar® bag. Oxygen, carbon dioxide, and methane readings will be collected using a Geotech GEM 5000 gas extraction monitor at the sample location from the Tedlar® bag containing purged air.
- Samples will be collected and packed in laboratory supplied containers and transported in accordance with the laboratory container, preservation, shipping, and packaging requirements.

- In addition, sampling of JS-MW-06, JS-MW-16 and JS-MW-19 and analysis of samples for VOCs is recommended for September 2026 to continue to monitor groundwater concentration trends along the eastern property boundary of the Joslyn South Parcel. Analysis of the samples by Method 8260C will be performed by Merit. The standard operating procedure for Method 8260C is included in **Attachment 5**.

Laboratory Analytical Methods

Groundwater samples will be analyzed for VOCs by the project laboratory Method 8260C for groundwater and TO-15 for soil gas. Relevant laboratory SOPs (**Attachment 5**) and TGIs (**Attachment 2**) are summarized in **Table 1** below.

Table 1: Index of Standard Operating Procedures (SOP) and Technical Guidance Instructions (TGI)

Laboratory SOP	Volatile Organic Compounds by Gas Chromatography/ Mass Spectrometry Method SW-846 8260C/ EPA 624.1
	Volatile Organic Compounds by Gas Chromatography/ Mass Spectrometry Method TO-15
Arcadis TGI	Soil Description
	Installation of Soil Vapor Probes
	Sub-Slab and Soil Vapor Sampling Using Whole Air Canisters
	Low Flow Groundwater Purging and Sampling Procedures for Monitoring Wells

Quality Assurance/Quality Control Procedures

Field Quality Assurance / Quality Control

Field Quality Assurance/Quality Control Procedures (QA/QC) samples will be collected during field sampling include:

- Field duplicate samples for groundwater and soil gas will be collected at a minimum frequency of 1 per 10 or fewer investigative samples. Field duplicate samples will be analyzed to assess the precision of the field sample collection procedures.
- Sufficient sample volume will be provided to the laboratory (as necessary) for matrix spike and spike duplicate (MS/MSD) analyses for groundwater. The data from MS/MSD analyses provides an indication of the precision and accuracy of the analytical method relative to the sample matrix. Samples for MS/MSD analysis will be designated at a minimum frequency of 1 per 20 or fewer samples.

Groundwater samples will be collected in laboratory supplied bottles and soil gas samples will be collected in laboratory provided SUMMA® canisters, packed in laboratory supplied shipping containers, and transported in accordance with the laboratory container, preservation, shipping, and packaging requirements.

Laboratory Quality Assurance / Quality Control

Laboratory QA/QC requirements for the analysis of groundwater and soil gas samples include analyzing method blanks, initial calibration verification standards, continuing calibration verification standards, MS/MSD samples, and laboratory Control Samples (LCS). The analysis frequency for these QA/QC samples is identified in the applicable laboratory SOP provided in **Attachment 5**. The acceptance criteria for these QC checks will be consistent with the analytical methods and laboratory SOP.

Laboratory Report Deliverables

Laboratory reports for samples collected will consist of the following data deliverables:

1. Case Narrative:
    a. Date of issuance
    b. Project name and number
    c. Any deviations from intended analytical strategy
    d. Condition of samples "as received"
    e. Discussion of whether sample holding times were met
    f. Discussion of technical problems or other observations that may have created analytical difficulties
    g. Discussion of any laboratory quality control checks that failed to meet project criteria
2. Chemistry Data Package
    a. Dates of sample collection, receipt, preparation, and analysis
    b. Cross-reference of laboratory to project sample identification numbers
    c. Description of data qualifiers used
    d. Methods of sample preparation and analysis
    e. Sample results in tabular format
    f. Method blank data, surrogate data, LCS data, duplicate sample data, MS/MSD data,
    g. Fully executed chain-of-custody document

Data Review and Validation

Upon receipt of the final Level II data packages from the project laboratories a Tier II data review and validation will be completed. The data review will evaluate the final analytical results, holding time period compliance, equipment blank sample data, field duplicate sample data, method blank data, LCS data, laboratory duplicate data, surrogate compound spike data, and MS/MSD sample data. Data will be reviewed in accordance with the USEPA National Functional Guidelines for Organic Superfund Methods Data Review, EPA 540-R-20-005, November 2020 (with reference to the historical USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, OSWER 9240.1-05A-P, October 1999 as appropriate), and USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA 542-R-20-006, November 2020.

Completion Reporting

Upon completion of field activities, a completion report will be prepared and submitted. The completion report will include a summary of the following:

- Brief description of the field activities performed
- Boring and SVMP Construction logs
- Analytical results from the initial sampling event
- Discussion of results and path forward

References

Arcadis 2024. 2023 Joslyn South Parcel Groundwater Sampling Summary Report, RACER Trust, Pontiac, Michigan, August 13, 2024.

EGLE. 2022. SSVIAC for RACER PNC Joslyn South Parcel Property Table1: Residential Part 201 SSVIAC or Part 213 VIAP STTLs, April 21, 2022.

U.S. Environmental Protection Agency (USEPA; Region I). 1996. Low-Stress (or Low-Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells – Revision 4. July 30, 1996; Revised September 19, 2017.

Tables:

Table 1 – Summary of Monitoring Well Analytical Results for Select Wells

Figures:

Figure 1 – Site Layout

Figure 2 – Joslyn South Parcel 2025 Groundwater Analytical Results

Figure 3 – Joslyn South Parcel Groundwater Trend Analysis

Figure 4 – Joslyn South Parcel Proposed Soil Vapor Monitoring Point Location

Attachments:

Attachment 1 – Groundwater Sampling Logs

Attachment 2 – Arcadis Technical Guidance Instructions (TGIs)

Attachment 3 – Analytical Laboratory Reports

Attachment 4 – Mann-Kendall Analysis

Attachment 5 – Laboratory Standard Operating Procedures (SOPs)

Tables

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-06	JS-MW-06	JS-MW-06	JS-MW-06
							Date Collected	6/19/2023	12/14/2023	9/24/2024	9/10/2025
VOCs											
1,1,1,2-Tetrachloroethane	ug/L	--	77	320	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1,1-Trichloroethane	ug/L	89	200	200	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1,2,2-Tetrachloroethane	ug/L	78	8.5	35.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1,2-Trichloroethane	ug/L	330	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1-Dichloroethane	ug/L	740	880	2,500	**4.7**	*40*		< 1 U	< 1 U	< 1 U	< 1 U
1,1-Dichloroethene	ug/L	130	7.0	7.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,2,3-Trichlorobenzene	ug/L	--	--	--	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
1,2,3-Trichloropropane	ug/L	--	42	120	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,2,3-Trimethylbenzene	ug/L	--	--	--	**43**	*150*		2	< 1 U	< 1 U	< 1 U
1,2,4-Trichlorobenzene	ug/L	99	70	70	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
1,2,4-Trimethylbenzene	ug/L	17	63	63	**25**	*120*		20	17	< 1 U	< 1 U
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	--	0.2	0.2	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
1,2-Dibromoethane (Ethylene dibromide)	ug/L	5.7	0.05	0.05	**0.13**	*0.39*		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichlorobenzene	ug/L	13	600	600	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichloroethane	ug/L	360	5.0	5.0	**1.4**	*5.1*		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichloropropane	ug/L	230	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,3,5-Trimethylbenzene	ug/L	45	72	72	**18**	*110*		< 1 U	< 1 U	< 1 U	< 1 U
1,3-Dichlorobenzene	ug/L	28	6.6	19.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,4-Dichlorobenzene	ug/L	17	75	75	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
2-Butanone (Methyl ethyl ketone) (MEK)	ug/L	2,200	13,000	38,000	**2,600**	*12,000*		< 25 U	< 25 U	< 25 U	< 25 U
2-Hexanone	ug/L	--	1,000	2,900	**--**	--		< 50 U	< 50 U	< 50 U	< 50 U
2-Methylnaphthalene	ug/L	19	260	750	**66**	*110*		< 5 U	< 5 U	< 5 U	< 5 U
2-Phenylbutane (sec-Butylbenzene)	ug/L	--	80	230	**270**	*400*		< 1 U	< 1 U	< 1 U	< 1 U
4-Methyl-2-pentanone (Methyl isobutyl ketone) (MIBK)	ug/L	--	1,800	5,200	**200**	*5,000*		< 50 U	< 50 U	< 50 U	< 50 U
Acetone	ug/L	1,700	730	2,100	**50,000**	*200,000*		< 50 U	< 50 U	< 50 U	< 50 U
Acrylonitrile	ug/L	2.0	3	11.0	**--**	--		< 2 U	< 2 U	< 2 U	< 2 U
Benzene	ug/L	200	5.0	5.0	**1.0**	*8.4*		< 1 U	< 1 U	< 1 U	< 1 U
Bromobenzene	ug/L	--	18	50	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Bromodichloromethane	ug/L	--	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Bromoform	ug/L	--	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Bromomethane (Methyl bromide)	ug/L	5.0	10	29	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Carbon disulfide	ug/L	--	800	2,300	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Carbon tetrachloride	ug/L	38	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chlorobenzene	ug/L	25	100	100	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chlorobromomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chloroethane	ug/L	1,100	430	1,700	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Chloroform (Trichloromethane)	ug/L	350	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chloromethane (Methyl chloride)	ug/L	--	260	1,100	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
cis-1,2-Dichloroethene	ug/L	620	70	70	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
cis-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Cymene (p-Isopropyltoluene)	ug/L	--	--	--	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Dibromochloromethane	ug/L	--	80	80	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Dibromomethane	ug/L	--	80	230	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Dichlorodifluoromethane (CFC-12)	ug/L	--	1,700	4,800	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-06	JS-MW-06	JS-MW-06	JS-MW-06
							Date Collected	6/19/2023	12/14/2023	9/24/2024	9/10/2025
Ethyl ether	ug/L	--	10	10	**--**	--		< 10 U	< 10 U	< 10 U	< 10 U
Ethylbenzene	ug/L	18	74	74	**2.8**	*28*		**16**	**14**	< 1 U	< 1 U
Hexachloroethane	ug/L	6.7	7.3	21.0	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Iodomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Isopropyl benzene	ug/L	28	800	2,300	**0.60**	*6.7*		< 5 U	< 5 U	< 5 U	< 5 U
m&p-Xylene	ug/L	--	--	--	**--**	--		26	17	< 2 U	< 2 U
Methyl tert butyl ether (MTBE)	ug/L	7,100	40	40	**250**	*810*		< 5 U	< 5 U	< 5 U	< 5 U
Methylene chloride	ug/L	1,500	5.0	5.0	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Naphthalene	ug/L	11	520	1,500	**4.2**	*12*		< 5 U	< 5 U	< 5 U	< 5 U
N-Butylbenzene	ug/L	--	80	230	**44**	*360*		< 1 U	< 1 U	< 1 U	< 1 U
N-Propylbenzene	ug/L	--	80	230	**43**	*970*		3	3	< 1 U	< 1 U
o-Xylene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Styrene	ug/L	80	100	100	**33**	*170*		< 1 U	< 1 U	< 1 U	< 1 U
tert-Butylbenzene	ug/L	--	80	230	**0.077**	*0.71*		< 1 U	< 1 U	< 1 U	< 1 U
Tetrachloroethene	ug/L	60	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Tetrahydrofuran	ug/L	11,000	95	270	**--**	--		< 90 U	< 90 U	< 90 U	< 90 U
Toluene	ug/L	270	790	790	**300**	*6,600*		< 1 U	< 1 U	< 1 U	< 1 U
trans-1,2-Dichloroethene	ug/L	1,500	100	100	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
trans-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
trans-1,4-Dichloro-2-butene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Trichloroethene	ug/L	200	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Trichlorofluoromethane (CFC-11)	ug/L	--	2,600	7,300	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Vinyl chloride	ug/L	13	2.0	2.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Xylene, Total	ug/L	49	280	280	**75**	*410*		26	17	< 2 U	< 2 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-16	JS-MW-16	JS-MW-16	JS-MW-16	JS-MW-16
							Date Collected	3/9/2023	6/22/2023	9/25/2023	12/18/2023	9/24/2024
VOCs												
1,1,1,2-Tetrachloroethane	ug/L	--	77	320	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,1,1-Trichloroethane	ug/L	89	200	200	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,1,2,2-Tetrachloroethane	ug/L	78	8.5	35.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,1,2-Trichloroethane	ug/L	330	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,1-Dichloroethane	ug/L	740	880	2,500	**4.7**	*40*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,1-Dichloroethene	ug/L	130	7.0	7.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,2,3-Trichlorobenzene	ug/L	--	--	--	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
1,2,3-Trichloropropane	ug/L	--	42	120	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,2,3-Trimethylbenzene	ug/L	--	--	--	**43**	*150*		2	3	3	4	6
1,2,4-Trichlorobenzene	ug/L	99	70	70	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
1,2,4-Trimethylbenzene	ug/L	17	63	63	**25**	*120*		2	13	22	21	11
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	--	0.2	0.2	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
1,2-Dibromoethane (Ethylene dibromide)	ug/L	5.7	0.05	0.05	**0.13**	*0.39*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichlorobenzene	ug/L	13	600	600	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichloroethane	ug/L	360	5.0	5.0	**1.4**	*5.1*		***12***	**3**	1	1	< 1 U
1,2-Dichloropropane	ug/L	230	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,3,5-Trimethylbenzene	ug/L	45	72	72	**18**	*110*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,3-Dichlorobenzene	ug/L	28	6.6	19.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
1,4-Dichlorobenzene	ug/L	17	75	75	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
2-Butanone (Methyl ethyl ketone) (MEK)	ug/L	2,200	13,000	38,000	**2,600**	*12,000*		< 25 U	< 25 U	< 25 U	< 25 U	< 25 U
2-Hexanone	ug/L	--	1,000	2,900	**--**	--		< 50 U	< 50 U	< 50 U	< 50 U	< 50 U
2-Methylnaphthalene	ug/L	19	260	750	**66**	*110*		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
2-Phenylbutane (sec-Butylbenzene)	ug/L	--	80	230	**270**	*400*		< 1 U	< 1 U	1	1	< 1 U
4-Methyl-2-pentanone (Methyl isobutyl ketone) (MIBK)	ug/L	--	1,800	5,200	**200**	*5,000*		< 50 U	< 50 U	< 50 U	< 50 U	< 50 U
Acetone	ug/L	1,700	730	2,100	**50,000**	*200,000*		< 50 U	< 50 U	< 50 U	< 50 U	< 50 U
Acrylonitrile	ug/L	2.0	3	11.0	**--**	--		< 2 U	< 2 U	< 2 U	< 2 U	< 2 U
Benzene	ug/L	200	5.0	5.0	**1.0**	*8.4*		**4**	**3**	**2**	**3**	**7**
Bromobenzene	ug/L	--	18	50	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Bromodichloromethane	ug/L	--	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Bromoform	ug/L	--	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Bromomethane (Methyl bromide)	ug/L	5.0	10	29	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Carbon disulfide	ug/L	--	800	2,300	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Carbon tetrachloride	ug/L	38	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Chlorobenzene	ug/L	25	100	100	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Chlorobromomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Chloroethane	ug/L	1,100	430	1,700	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Chloroform (Trichloromethane)	ug/L	350	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Chloromethane (Methyl chloride)	ug/L	--	260	1,100	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
cis-1,2-Dichloroethene	ug/L	620	70	70	**--**	--		< 1 U	< 1 U	2	< 1 U	< 1 U
cis-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Cymene (p-Isopropyltoluene)	ug/L	--	--	--	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Dibromochloromethane	ug/L	--	80	80	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Dibromomethane	ug/L	--	80	230	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Dichlorodifluoromethane (CFC-12)	ug/L	--	1,700	4,800	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-16	JS-MW-16	JS-MW-16	JS-MW-16	JS-MW-16
							Date Collected	3/9/2023	6/22/2023	9/25/2023	12/18/2023	9/24/2024
Ethyl ether	ug/L	--	10	10	**--**	--		< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Ethylbenzene	ug/L	18	74	74	**2.8**	*28*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Hexachloroethane	ug/L	6.7	7.3	21.0	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Iodomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Isopropyl benzene	ug/L	28	800	2,300	**0.60**	*6.7*		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
m&p-Xylene	ug/L	--	--	--	**--**	--		5	15	10	10	19
Methyl tert butyl ether (MTBE)	ug/L	7,100	40	40	**250**	*810*		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Methylene chloride	ug/L	1,500	5.0	5.0	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
Naphthalene	ug/L	11	520	1,500	**4.2**	*12*		< 5 U	< 5 U	< 5 U	< 5 U	< 5 U
N-Butylbenzene	ug/L	--	80	230	**44**	*360*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
N-Propylbenzene	ug/L	--	80	230	**43**	*970*		< 1 U	5	9	9	8
o-Xylene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Styrene	ug/L	80	100	100	**33**	*170*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
tert-Butylbenzene	ug/L	--	80	230	**0.077**	*0.71*		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Tetrachloroethene	ug/L	60	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Tetrahydrofuran	ug/L	11,000	95	270	**--**	--		< 90 U	< 90 U	< 90 U	< 90 U	< 90 U
Toluene	ug/L	270	790	790	**300**	*6,600*		< 1 U	< 1 U	< 1 U	< 1 U	1
trans-1,2-Dichloroethene	ug/L	1,500	100	100	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
trans-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
trans-1,4-Dichloro-2-butene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Trichloroethene	ug/L	200	5.0	5.0	**--**	--		< 1 U	< 1 U	1	< 1 U	< 1 U
Trichlorofluoromethane (CFC-11)	ug/L	--	2,600	7,300	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Vinyl chloride	ug/L	13	2.0	2.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Xylene, Total	ug/L	49	280	280	**75**	*410*		5	15	10	10	19

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-16	JS-MW-16
							Date Collected	9/10/2025	12/11/2025
VOCs									
1,1,1,2-Tetrachloroethane	ug/L	--	77	320	**--**	--		< 1 U	< 1 U [< 1 U]
1,1,1-Trichloroethane	ug/L	89	200	200	**--**	--		< 1 U	< 1 U [< 1 U]
1,1,2,2-Tetrachloroethane	ug/L	78	8.5	35.0	**--**	--		< 1 U	< 1 U [< 1 U]
1,1,2-Trichloroethane	ug/L	330	5.0	5.0	**--**	--		< 1 U	< 1 U [< 1 U]
1,1-Dichloroethane	ug/L	740	880	2,500	**4.7**	*40*		< 1 U	< 1 U [< 1 U]
1,1-Dichloroethene	ug/L	130	7.0	7.0	**--**	--		< 1 U	< 1 U [< 1 U]
1,2,3-Trichlorobenzene	ug/L	--	--	--	**--**	--		< 5 U	< 5 U [< 5 U]
1,2,3-Trichloropropane	ug/L	--	42	120	**--**	--		< 1 U	< 1 U [< 1 U]
1,2,3-Trimethylbenzene	ug/L	--	--	--	**43**	*150*		7	2 [2]
1,2,4-Trichlorobenzene	ug/L	99	70	70	**--**	--		< 5 U	< 5 U [< 5 U]
1,2,4-Trimethylbenzene	ug/L	17	63	63	**25**	*120*		15	5 [5]
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	--	0.2	0.2	**--**	--		< 5 U	< 5 U [< 5 U]
1,2-Dibromoethane (Ethylene dibromide)	ug/L	5.7	0.05	0.05	**0.13**	*0.39*		< 1 U	< 1 U [< 1 U]
1,2-Dichlorobenzene	ug/L	13	600	600	**--**	--		< 1 U	< 1 U [< 1 U]
1,2-Dichloroethane	ug/L	360	5.0	5.0	**1.4**	*5.1*		**5**	***7 [7]***
1,2-Dichloropropane	ug/L	230	5.0	5.0	**--**	--		< 1 U	< 1 U [< 1 U]
1,3,5-Trimethylbenzene	ug/L	45	72	72	**18**	*110*		< 1 U	< 1 U [< 1 U]
1,3-Dichlorobenzene	ug/L	28	6.6	19.0	**--**	--		< 1 U	< 1 U [< 1 U]
1,4-Dichlorobenzene	ug/L	17	75	75	**--**	--		< 1 U	< 1 U [< 1 U]
2-Butanone (Methyl ethyl ketone) (MEK)	ug/L	2,200	13,000	38,000	**2,600**	*12,000*		< 25 U	< 25 U [< 25 U]
2-Hexanone	ug/L	--	1,000	2,900	**--**	--		< 50 U	< 50 U [< 50 U]
2-Methylnaphthalene	ug/L	19	260	750	**66**	*110*		< 5 U	< 5 U [< 5 U]
2-Phenylbutane (sec-Butylbenzene)	ug/L	--	80	230	**270**	*400*		< 1 U	< 1 U [< 1 U]
4-Methyl-2-pentanone (Methyl isobutyl ketone) (MIBK)	ug/L	--	1,800	5,200	**200**	*5,000*		< 50 U	< 50 U [< 50 U]
Acetone	ug/L	1,700	730	2,100	**50,000**	*200,000*		< 50 U	< 50 U [< 50 U]
Acrylonitrile	ug/L	2.0	3	11.0	**--**	--		< 2 U	< 2 U [< 2 U]
Benzene	ug/L	200	5.0	5.0	**1.0**	*8.4*		***9***	**2 [2]**
Bromobenzene	ug/L	--	18	50	**--**	--		< 1 U	< 1 U [< 1 U]
Bromodichloromethane	ug/L	--	80	80	**--**	--		< 1 U	< 1 U [< 1 U]
Bromoform	ug/L	--	80	80	**--**	--		< 1 U	< 1 U [< 1 U]
Bromomethane (Methyl bromide)	ug/L	5.0	10	29	**--**	--		< 5 U	< 5 U [< 5 U]
Carbon disulfide	ug/L	--	800	2,300	**--**	--		< 5 U	< 5 U [< 5 U]
Carbon tetrachloride	ug/L	38	5.0	5.0	**--**	--		< 1 U	< 1 U [< 1 U]
Chlorobenzene	ug/L	25	100	100	**--**	--		< 1 U	< 1 U [< 1 U]
Chlorobromomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U [< 1 U]
Chloroethane	ug/L	1,100	430	1,700	**--**	--		< 5 U	< 5 U [< 5 U]
Chloroform (Trichloromethane)	ug/L	350	80	80	**--**	--		< 1 U	< 1 U [< 1 U]
Chloromethane (Methyl chloride)	ug/L	--	260	1,100	**--**	--		< 5 U	< 5 U [< 5 U]
cis-1,2-Dichloroethene	ug/L	620	70	70	**--**	--		< 1 U	< 1 U [< 1 U]
cis-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U [< 1 U]
Cymene (p-Isopropyltoluene)	ug/L	--	--	--	**--**	--		< 5 U	< 5 U [< 5 U]
Dibromochloromethane	ug/L	--	80	80	**--**	--		< 5 U	< 5 U [< 5 U]
Dibromomethane	ug/L	--	80	230	**--**	--		< 5 U	< 5 U [< 5 U]
Dichlorodifluoromethane (CFC-12)	ug/L	--	1,700	4,800	**--**	--		< 5 U	< 5 U [< 5 U]

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-16	JS-MW-16
							Date Collected	9/10/2025	12/11/2025
Ethyl ether	ug/L	--	10	10	**--**	--		< 10 U	< 10 U [< 10 U]
Ethylbenzene	ug/L	18	74	74	**2.8**	*28*		< 1 U	< 1 U [< 1 U]
Hexachloroethane	ug/L	6.7	7.3	21.0	**--**	--		< 5 U	< 5 U [< 5 U]
Iodomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U [< 1 U]
Isopropyl benzene	ug/L	28	800	2,300	**0.60**	*6.7*		**5**	< 5 U [< 5 U]
m&p-Xylene	ug/L	--	--	--	**--**	--		32	< 2 U [< 2 U]
Methyl tert butyl ether (MTBE)	ug/L	7,100	40	40	**250**	*810*		< 5 U	< 5 U [< 5 U]
Methylene chloride	ug/L	1,500	5.0	5.0	**--**	--		< 5 U	< 5 U [< 5 U]
Naphthalene	ug/L	11	520	1,500	**4.2**	*12*		< 5 U	< 5 U [< 5 U]
N-Butylbenzene	ug/L	--	80	230	**44**	*360*		< 1 U	< 1 U [< 1 U]
N-Propylbenzene	ug/L	--	80	230	**43**	*970*		7	3 [3]
o-Xylene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U [< 1 U]
Styrene	ug/L	80	100	100	**33**	*170*		< 1 U	< 1 U [< 1 U]
tert-Butylbenzene	ug/L	--	80	230	**0.077**	*0.71*		< 1 U	< 1 U [< 1 U]
Tetrachloroethene	ug/L	60	5.0	5.0	**--**	--		< 1 U	< 1 U [< 1 U]
Tetrahydrofuran	ug/L	11,000	95	270	**--**	--		< 90 U	< 90 U [< 90 U]
Toluene	ug/L	270	790	790	**300**	*6,600*		1	< 1 U [< 1 U]
trans-1,2-Dichloroethene	ug/L	1,500	100	100	**--**	--		< 1 U	< 1 U [< 1 U]
trans-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U [< 1 U]
trans-1,4-Dichloro-2-butene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U [< 1 U]
Trichloroethene	ug/L	200	5.0	5.0	**--**	--		< 1 U	< 1 U [< 1 U]
Trichlorofluoromethane (CFC-11)	ug/L	--	2,600	7,300	**--**	--		< 1 U	< 1 U [< 1 U]
Vinyl chloride	ug/L	13	2.0	2.0	**--**	--		< 1 U	< 1 U [< 1 U]
Xylene, Total	ug/L	49	280	280	**75**	*410*		32	12 [12]

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-19	JS-MW-19	JS-MW-19	JS-MW-19
							Date Collected	3/9/2023	6/20/2023	9/25/2023	12/15/2023
VOCs											
1,1,1,2-Tetrachloroethane	ug/L	--	77	320	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1,1-Trichloroethane	ug/L	89	200	200	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1,2,2-Tetrachloroethane	ug/L	78	8.5	35.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1,2-Trichloroethane	ug/L	330	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,1-Dichloroethane	ug/L	740	880	2,500	**4.7**	*40*		< 1 U	< 1 U	< 1 U	< 1 U
1,1-Dichloroethene	ug/L	130	7.0	7.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,2,3-Trichlorobenzene	ug/L	--	--	--	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
1,2,3-Trichloropropane	ug/L	--	42	120	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,2,3-Trimethylbenzene	ug/L	--	--	--	**43**	*150*		< 1 U	< 1 U	< 1 U	< 1 U
1,2,4-Trichlorobenzene	ug/L	99	70	70	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
1,2,4-Trimethylbenzene	ug/L	17	63	63	**25**	*120*		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	--	0.2	0.2	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
1,2-Dibromoethane (Ethylene dibromide)	ug/L	5.7	0.05	0.05	**0.13**	*0.39*		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichlorobenzene	ug/L	13	600	600	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichloroethane	ug/L	360	5.0	5.0	**1.4**	*5.1*		< 1 U	< 1 U	< 1 U	< 1 U
1,2-Dichloropropane	ug/L	230	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,3,5-Trimethylbenzene	ug/L	45	72	72	**18**	*110*		< 1 U	< 1 U	< 1 U	< 1 U
1,3-Dichlorobenzene	ug/L	28	6.6	19.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
1,4-Dichlorobenzene	ug/L	17	75	75	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
2-Butanone (Methyl ethyl ketone) (MEK)	ug/L	2,200	13,000	38,000	**2,600**	*12,000*		< 25 U	< 25 U	< 25 U	< 25 U
2-Hexanone	ug/L	--	1,000	2,900	**--**	--		< 50 U	< 50 U	< 50 U	< 50 U
2-Methylnaphthalene	ug/L	19	260	750	**66**	*110*		< 5 U	< 5 U	< 5 U	< 5 U
2-Phenylbutane (sec-Butylbenzene)	ug/L	--	80	230	**270**	*400*		< 1 U	< 1 U	< 1 U	< 1 U
4-Methyl-2-pentanone (Methyl isobutyl ketone) (MIBK)	ug/L	--	1,800	5,200	**200**	*5,000*		< 50 U	< 50 U	< 50 U	< 50 U
Acetone	ug/L	1,700	730	2,100	**50,000**	*200,000*		< 50 U	< 50 U	< 50 U	< 50 U
Acrylonitrile	ug/L	2.0	3	11.0	**--**	--		< 2 U	< 2 U	< 2 U	< 2 U
Benzene	ug/L	200	5.0	5.0	**1.0**	*8.4*		< 1 U	**4**	**3**	< 1 U
Bromobenzene	ug/L	--	18	50	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Bromodichloromethane	ug/L	--	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Bromoform	ug/L	--	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Bromomethane (Methyl bromide)	ug/L	5.0	10	29	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Carbon disulfide	ug/L	--	800	2,300	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Carbon tetrachloride	ug/L	38	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chlorobenzene	ug/L	25	100	100	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chlorobromomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chloroethane	ug/L	1,100	430	1,700	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Chloroform (Trichloromethane)	ug/L	350	80	80	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Chloromethane (Methyl chloride)	ug/L	--	260	1,100	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
cis-1,2-Dichloroethene	ug/L	620	70	70	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
cis-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Cymene (p-Isopropyltoluene)	ug/L	--	--	--	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Dibromochloromethane	ug/L	--	80	80	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Dibromomethane	ug/L	--	80	230	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Dichlorodifluoromethane (CFC-12)	ug/L	--	1,700	4,800	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-19	JS-MW-19	JS-MW-19	JS-MW-19
							Date Collected	3/9/2023	6/20/2023	9/25/2023	12/15/2023
Ethyl ether	ug/L	--	10	10	**--**	--		< 10 U	< 10 U	< 10 U	< 10 U
Ethylbenzene	ug/L	18	74	74	**2.8**	*28*		< 1 U	< 1 U	< 1 U	< 1 U
Hexachloroethane	ug/L	6.7	7.3	21.0	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Iodomethane	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Isopropyl benzene	ug/L	28	800	2,300	**0.60**	*6.7*		< 5 U	< 5 U	< 5 U	< 5 U
m&p-Xylene	ug/L	--	--	--	**--**	--		< 2 U	< 2 U	< 2 U	< 2 U
Methyl tert butyl ether (MTBE)	ug/L	7,100	40	40	**250**	*810*		< 5 U	< 5 U	< 5 U	< 5 U
Methylene chloride	ug/L	1,500	5.0	5.0	**--**	--		< 5 U	< 5 U	< 5 U	< 5 U
Naphthalene	ug/L	11	520	1,500	**4.2**	*12*		< 5 U	< 5 U	< 5 U	< 5 U
N-Butylbenzene	ug/L	--	80	230	**44**	*360*		< 1 U	< 1 U	< 1 U	< 1 U
N-Propylbenzene	ug/L	--	80	230	**43**	*970*		2	< 1 U	< 1 U	< 1 U
o-Xylene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Styrene	ug/L	80	100	100	**33**	*170*		< 1 U	< 1 U	< 1 U	< 1 U
tert-Butylbenzene	ug/L	--	80	230	**0.077**	*0.71*		< 1 U	< 1 U	< 1 U	< 1 U
Tetrachloroethene	ug/L	60	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Tetrahydrofuran	ug/L	11,000	95	270	**--**	--		< 90 U	< 90 U	< 90 U	< 90 U
Toluene	ug/L	270	790	790	**300**	*6,600*		< 1 U	< 1 U	< 1 U	< 1 U
trans-1,2-Dichloroethene	ug/L	1,500	100	100	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
trans-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
trans-1,4-Dichloro-2-butene	ug/L	--	--	--	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Trichloroethene	ug/L	200	5.0	5.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Trichlorofluoromethane (CFC-11)	ug/L	--	2,600	7,300	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Vinyl chloride	ug/L	13	2.0	2.0	**--**	--		< 1 U	< 1 U	< 1 U	< 1 U
Xylene, Total	ug/L	49	280	280	**75**	*410*		< 2 U	< 2 U	< 2 U	< 2 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-19	JS-MW-19
							Date Collected	9/24/2024	9/10/2025
VOCs									
1,1,1,2-Tetrachloroethane	ug/L	--	77	320	**--**	--		< 1 U [< 1 U]	< 1 U
1,1,1-Trichloroethane	ug/L	89	200	200	**--**	--		< 1 U [< 1 U]	< 1 U
1,1,2,2-Tetrachloroethane	ug/L	78	8.5	35.0	**--**	--		< 1 U [< 1 U]	< 1 U
1,1,2-Trichloroethane	ug/L	330	5.0	5.0	**--**	--		< 1 U [< 1 U]	< 1 U
1,1-Dichloroethane	ug/L	740	880	2,500	**4.7**	*40*		< 1 U [< 1 U]	< 1 U
1,1-Dichloroethene	ug/L	130	7.0	7.0	**--**	--		< 1 U [< 1 U]	< 1 U
1,2,3-Trichlorobenzene	ug/L	--	--	--	**--**	--		< 5 U [< 5 U]	< 5 U
1,2,3-Trichloropropane	ug/L	--	42	120	**--**	--		< 1 U [< 1 U]	< 1 U
1,2,3-Trimethylbenzene	ug/L	--	--	--	**43**	*150*		< 1 U [< 1 U]	< 1 U
1,2,4-Trichlorobenzene	ug/L	99	70	70	**--**	--		< 5 U [< 5 U]	< 5 U
1,2,4-Trimethylbenzene	ug/L	17	63	63	**25**	*120*		< 1 U [< 1 U]	< 1 U
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	--	0.2	0.2	**--**	--		< 5 U [< 5 U]	< 5 U
1,2-Dibromoethane (Ethylene dibromide)	ug/L	5.7	0.05	0.05	**0.13**	*0.39*		< 1 U [< 1 U]	< 1 U
1,2-Dichlorobenzene	ug/L	13	600	600	**--**	--		< 1 U [< 1 U]	< 1 U
1,2-Dichloroethane	ug/L	360	5.0	5.0	**1.4**	*5.1*		< 1 U [< 1 U]	< 1 U
1,2-Dichloropropane	ug/L	230	5.0	5.0	**--**	--		< 1 U [< 1 U]	< 1 U
1,3,5-Trimethylbenzene	ug/L	45	72	72	**18**	*110*		< 1 U [< 1 U]	< 1 U
1,3-Dichlorobenzene	ug/L	28	6.6	19.0	**--**	--		< 1 U [< 1 U]	< 1 U
1,4-Dichlorobenzene	ug/L	17	75	75	**--**	--		< 1 U [< 1 U]	< 1 U
2-Butanone (Methyl ethyl ketone) (MEK)	ug/L	2,200	13,000	38,000	**2,600**	*12,000*		< 25 U [< 25 U]	< 25 U
2-Hexanone	ug/L	--	1,000	2,900	**--**	--		< 50 U [< 50 U]	< 50 U
2-Methylnaphthalene	ug/L	19	260	750	**66**	*110*		< 5 U [< 5 U]	< 5 U
2-Phenylbutane (sec-Butylbenzene)	ug/L	--	80	230	**270**	*400*		< 1 U [< 1 U]	< 1 U
4-Methyl-2-pentanone (Methyl isobutyl ketone) (MIBK)	ug/L	--	1,800	5,200	**200**	*5,000*		< 50 U [< 50 U]	< 50 U
Acetone	ug/L	1,700	730	2,100	**50,000**	*200,000*		< 50 U [< 50 U]	< 50 U
Acrylonitrile	ug/L	2.0	3	11.0	**--**	--		< 2 U [< 2 U]	< 2 U
Benzene	ug/L	200	5.0	5.0	**1.0**	*8.4*		< 1 U [< 1 U]	< 1 U
Bromobenzene	ug/L	--	18	50	**--**	--		< 1 U [< 1 U]	< 1 U
Bromodichloromethane	ug/L	--	80	80	**--**	--		< 1 U [< 1 U]	< 1 U
Bromoform	ug/L	--	80	80	**--**	--		< 1 U [< 1 U]	< 1 U
Bromomethane (Methyl bromide)	ug/L	5.0	10	29	**--**	--		< 5 U [< 5 U]	< 5 U
Carbon disulfide	ug/L	--	800	2,300	**--**	--		< 5 U [< 5 U]	< 5 U
Carbon tetrachloride	ug/L	38	5.0	5.0	**--**	--		< 1 U [< 1 U]	< 1 U
Chlorobenzene	ug/L	25	100	100	**--**	--		< 1 U [< 1 U]	< 1 U
Chlorobromomethane	ug/L	--	--	--	**--**	--		< 1 U [< 1 U]	< 1 U
Chloroethane	ug/L	1,100	430	1,700	**--**	--		< 5 U [< 5 U]	< 5 U
Chloroform (Trichloromethane)	ug/L	350	80	80	**--**	--		< 1 U [< 1 U]	< 1 U
Chloromethane (Methyl chloride)	ug/L	--	260	1,100	**--**	--		< 5 U [< 5 U]	< 5 U
cis-1,2-Dichloroethene	ug/L	620	70	70	**--**	--		< 1 U [< 1 U]	< 1 U
cis-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U [< 1 U]	< 1 U
Cymene (p-Isopropyltoluene)	ug/L	--	--	--	**--**	--		< 5 U [< 5 U]	< 5 U
Dibromochloromethane	ug/L	--	80	80	**--**	--		< 5 U [< 5 U]	< 5 U
Dibromomethane	ug/L	--	80	230	**--**	--		< 5 U [< 5 U]	< 5 U
Dichlorodifluoromethane (CFC-12)	ug/L	--	1,700	4,800	**--**	--		< 5 U [< 5 U]	< 5 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Chemical Name	Units	Groundwater Surface Water Interface	Residential Drinking Water	Nonresidential Drinking Water	Res Joslyn SSVIAC BASE	NR Joslyn SSVIAC <50k SOG	Location ID	JS-MW-19	JS-MW-19
							Date Collected	9/24/2024	9/10/2025
Ethyl ether	ug/L	--	10	10	**--**	--		< 10 U [< 10 U]	< 10 U
Ethylbenzene	ug/L	18	74	74	**2.8**	*28*		< 1 U [< 1 U]	< 1 U
Hexachloroethane	ug/L	6.7	7.3	21.0	**--**	--		< 5 U [< 5 U]	< 5 U
Iodomethane	ug/L	--	--	--	**--**	--		< 1 U [< 1 U]	< 1 U
Isopropyl benzene	ug/L	28	800	2,300	**0.60**	*6.7*		< 5 U [< 5 U]	< 5 U
m&p-Xylene	ug/L	--	--	--	**--**	--		< 2 U [< 2 U]	< 2 U
Methyl tert butyl ether (MTBE)	ug/L	7,100	40	40	**250**	*810*		< 5 U [< 5 U]	< 5 U
Methylene chloride	ug/L	1,500	5.0	5.0	**--**	--		< 5 U [< 5 U]	< 5 U
Naphthalene	ug/L	11	520	1,500	**4.2**	*12*		< 5 U [< 5 U]	< 5 U
N-Butylbenzene	ug/L	--	80	230	**44**	*360*		< 1 U [< 1 U]	< 1 U
N-Propylbenzene	ug/L	--	80	230	**43**	*970*		< 1 U [< 1 U]	< 1 U
o-Xylene	ug/L	--	--	--	**--**	--		< 1 U [< 1 U]	< 1 U
Styrene	ug/L	80	100	100	**33**	*170*		< 1 U [< 1 U]	< 1 U
tert-Butylbenzene	ug/L	--	80	230	**0.077**	*0.71*		< 1 U [< 1 U]	< 1 U
Tetrachloroethene	ug/L	60	5.0	5.0	**--**	--		< 1 U [< 1 U]	< 1 U
Tetrahydrofuran	ug/L	11,000	95	270	**--**	--		< 90 U [< 90 U]	< 90 U
Toluene	ug/L	270	790	790	**300**	*6,600*		< 1 U [< 1 U]	< 1 U
trans-1,2-Dichloroethene	ug/L	1,500	100	100	**--**	--		< 1 U [< 1 U]	< 1 U
trans-1,3-Dichloropropene	ug/L	--	--	--	**--**	--		< 1 U [< 1 U]	< 1 U
trans-1,4-Dichloro-2-butene	ug/L	--	--	--	**--**	--		< 1 U [< 1 U]	< 1 U
Trichloroethene	ug/L	200	5.0	5.0	**--**	--		< 1 U [< 1 U]	< 1 U
Trichlorofluoromethane (CFC-11)	ug/L	--	2,600	7,300	**--**	--		< 1 U [< 1 U]	< 1 U
Vinyl chloride	ug/L	13	2.0	2.0	**--**	--		< 1 U [< 1 U]	< 1 U
Xylene, Total	ug/L	49	280	280	**75**	*410*		< 2 U [< 2 U]	< 2 U

Table 1
Summary of Monitoring Well Analytical Results for Select Wells
Joslyn South Parcel
RACER Trust Pontiac North Campus

Notes:

1) Criteria listed are from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Clean Up Criteria Requirements Table 1: Groundwater: Residential and Nonresidential, Part 201 Generic Cleanup Criteria and Screening Levels, October 12, 2023.
2) Criteria listed are from the EGLE Joslyn Site-Specific Criteria Evaluation dated May 3, 2022.
3) Nonresidential SSVIAC was calculated from the Residential EGLE site-specific criteria.
4) Grey shaded values denotes exceedance and/or equal to Michigan Groundwater Surface Water Interface criteria
5) Yellow highlighted values denotes exceedance and/or equal to Michigan Residential Drinking Water criteria
6) Orange highlighted values denotes exceedance and/or equal to Nonresidential Drinking Water criteria
7) Values in bold denotes exceedance and/or equal to Residential Joslyn site-specific volatilization to indoor air criteria
8) Italicized values denotes exceedance and/or equal to Nonresidential Joslyn site-specific volatilization to indoor air criteria <50k - Basement scenario
9) Duplicate analyses are presented in brackets.
10) Samples were analyzed by EPA Method SW5030C/8260C

Abbreviations:

<	Not detected above the laboratory reporting limit
ug/L	Micrograms per liter
U	Compound was analyzed for but not detected. The associated value is the compound quantitation limit.
BASE	Basement scenario
NA	Not Analyzed
NR	Nonresidential
RES	Residential
SOG	Slab-On-Grade scenario
SSVIAC	Site-specific volatilization to indoor air criteria
VOCs	Volatile Organic Compounds
<50k	Less than 50,000 square feet

Figures

SPO PARKING

FORMER BUILDING 25

SPO

FORMER BUILDING 15

FORMER PLANT 12

BUILDING 14

GLOBAL PROPULSION SYSTEMS

FORMER FIERO PARKING LOT

FORMER FIERO PLANT 17

GM WWTP

FORMER BUILDING 14S (PLANTS 5 AND 23)

JOSLYN SOUTH PARCEL

FORMER POWER HOUSE

USPS REGIONAL DISTRIBUTION CENTER

HARRIS LAKE

FORMER STORMWATER DETENTION FACILITY

PERRY PARK

OAKLAND PARK

W Chicago
E Chicago
W New York
E New York
Hollywood
W Colgate
E Colgate
W Walton Blvd
E Walton Blvd
Lehigh Ave
W Sheffield
E Sheffield
W Princeton
E Princeton
W Hopkins
E Hopkins
W Yale
E Yale
Price
W Ypsilanti
E Ypsilanti
E Ann Arbor
Alpine Ln
Bellmore Ln
Concord Ln
Deerfield Ln
Highwood
Northfield
Highwood Blvd
Laurel
Jaycee Park Rd
Joslyn Ave
Peacock
Clara
W Columbia
E Columbia
W Longfellow
E Longfellow
W Strathmore
E Strathmore
W Fairmount
E Fairmount
W Rutgers
E Rutgers
W Cornell
E Cornell
W Beverly Ave
E Beverly Ave
Baldwin Ave
4th St
Ivy
3rd Ave
2nd Ave
1st Ave
Beverly Ave
E Beverly Ave
E Tennyson
E Mansfield
E Madison
Le Baron
Wesbrook
Lenox
Markle
Raskob
E Kennett Rd
Lowell
Spence
W Tennyson
W Mansfield
Saint Louis Ave
W Kennett Rd
Dresden
Parkdale
Parkdale Ave
E Kennett Rd
N Merrimac St
S Merrimac
Owens St
Saint Clair St
Young
Wing
Portland
W Montcalm
E Montcalm
Lakeside Dr
Hillside Dr
Burt
City Line Rd
Le Grande
Garner
Hudson
Riker
McNeil St
Hood
W Rundell
Putnam
Pingree
Tacoma Ct
Hamilton
Jefferson
Whitfield
Virginia
Kimball
Grandie
Home
Cadillac
Poplar
Lewis
Adelaide
Harriette
Forest
Rose Ct
W Howard
Bennett
Foster
Tregent
Cesar E Chavez Ave
Chamberlain
Charlotte
Sheridan
Gingell Ct
N Saginaw St
Edison
Marquette
Wolfe
N Glenwood
Nelson
Hammond
Oliver
Ivy
N Perry
E Rundell
Kemp
Clarence
Beach
N Paddock
S Glenwood
Glenwood Ave

LEGEND

- JOSLYN PROPERTY BOUNDARY
- PROPERTY SOLD BY RACER
- GENERAL MOTORS, LLC (GM)
- CURRENT OR FORMER RACER PROPERTY

SPO – SERVICE PARTS OPERATION

USPS – UNITED STATES POSTAL SERVICE

WWTP – WASTEWATER TREATMENT PLANT

NOTE: ALL BOUNDARIES ARE APPROXIMATE

AERIAL SOURCE: GOOGLE EARTH PRO; IMAGE DATED MARCH 19, 2021

0 350 700

SCALE IN FEET

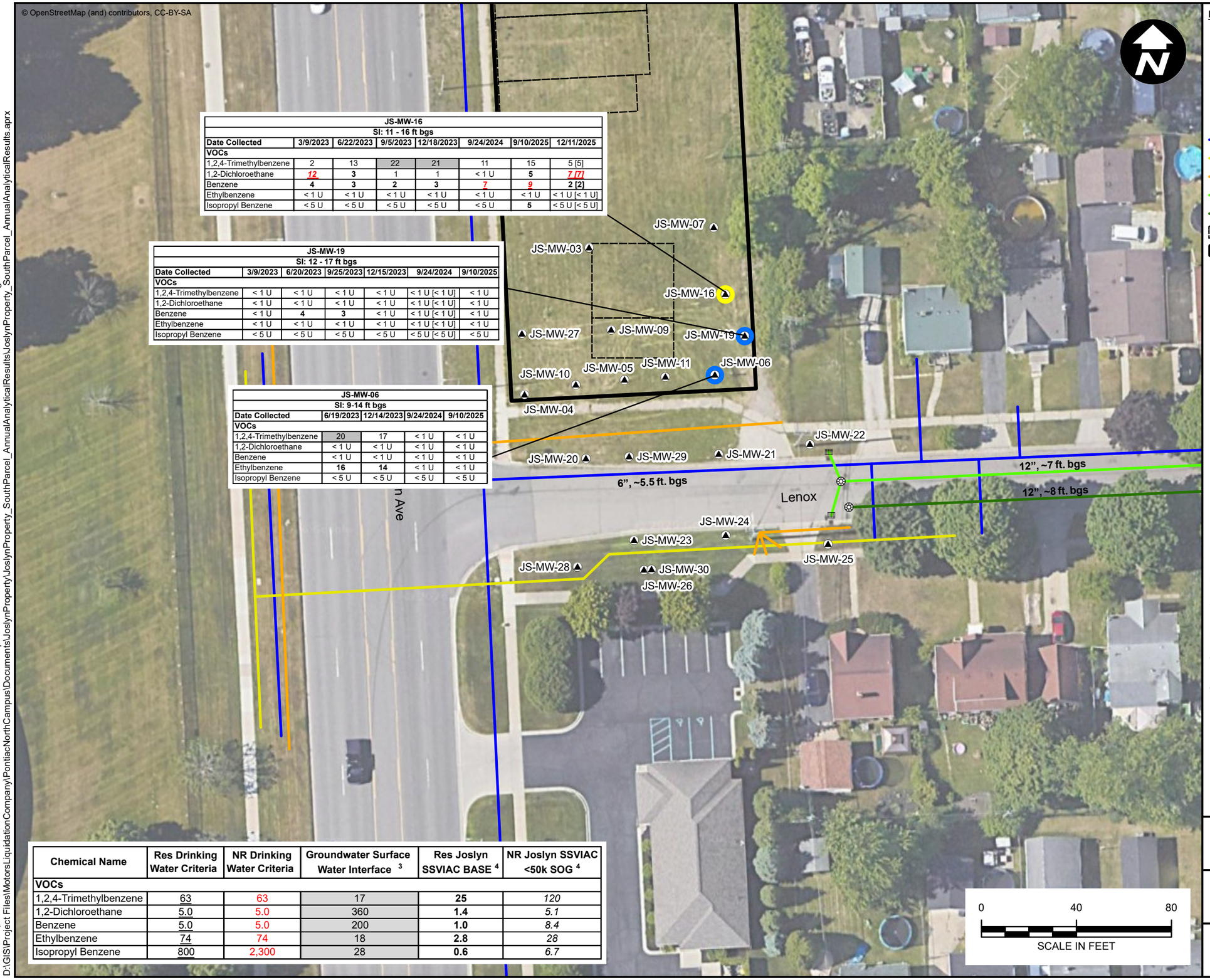
RACER TRUST
PONTIAC NORTH CAMPUS
PONTIAC, MICHIGAN

SITE LAYOUT

ARCADIS

FIGURE 1

CITY: NOVI, MI DIV: ENV DB: TRY PIC: J. Barrett PM: T. Linder TM: L. Crisp TR: PROJECT NUMBER: 30214041 PLOTTED: 4/7/2026 1:31 PM BY: TYarbrough
D:\GIS\Project Files\MotorsLiquidationCompany\PontiacNorthCampus\Documents\JoslynProperty\LenoxProperty_MonitoringPlan_2023\LenoxProperty_MonitoringPlan_2023.aprx



JS-MW-16							
SI: 11 - 16 ft bgs							
Date Collected	**3/9/2023**	**6/22/2023**	**9/5/2023**	**12/18/2023**	**9/24/2024**	**9/10/2025**	**12/11/2025**
VOCs							
1,2,4-Trimethylbenzene	2	13	22	21	11	15	5 [5]
1,2-Dichloroethane	***12***	**3**	1	1	< 1 U	**5**	***7 [7]***
Benzene	**4**	**3**	**2**	**3**	***7***	***9***	**2 [2]**
Ethylbenzene	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U [< 1 U]
Isopropyl Benzene	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	**5**	< 5 U [< 5 U]

JS-MW-19						
SI: 12 - 17 ft bgs						
Date Collected	**3/9/2023**	**6/20/2023**	**9/25/2023**	**12/15/2023**	**9/24/2024**	**9/10/2025**
VOCs						
1,2,4-Trimethylbenzene	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U [< 1 U]	< 1 U
1,2-Dichloroethane	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U [< 1 U]	< 1 U
Benzene	< 1 U	**4**	**3**	< 1 U	< 1 U [< 1 U]	< 1 U
Ethylbenzene	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U [< 1 U]	< 1 U
Isopropyl Benzene	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U [< 5 U]	< 5 U

JS-MW-06				
SI: 9-14 ft bgs				
Date Collected	**6/19/2023**	**12/14/2023**	**9/24/2024**	**9/10/2025**
VOCs				
1,2,4-Trimethylbenzene	20	17	< 1 U	< 1 U
1,2-Dichloroethane	< 1 U	< 1 U	< 1 U	< 1 U
Benzene	< 1 U	< 1 U	< 1 U	< 1 U
Ethylbenzene	**16**	**14**	< 1 U	< 1 U
Isopropyl Benzene	< 5 U	< 5 U	< 5 U	< 5 U

Chemical Name	Res Drinking Water Criteria	NR Drinking Water Criteria	Groundwater Surface Water Interface [3]	Res Joslyn SSVIAC BASE [4]	NR Joslyn SSVIAC <50k SOG [4]
VOCs					
1,2,4-Trimethylbenzene	63	63	17	**25**	*120*
1,2-Dichloroethane	5.0	5.0	360	**1.4**	*5.1*
Benzene	5.0	5.0	200	**1.0**	*8.4*
Ethylbenzene	74	74	18	**2.8**	*28*
Isopropyl Benzene	800	2,300	28	**0.6**	*6.7*

LEGEND

- MONITORING WELL
- MANHOLE
- CATCH BASIN
- EXCEEDS RESIDENTIAL JOSLYN SSVIAC IN 2025
- NO EXCEEDANCES OF JOSLYN SSVIAC IN 2025
- WATER
- GAS
- TELECOMMUNICATIONS
- STORM SEWER
- SANITARY SEWER
- HISTORIC SITE STRUCTURES
- PROPERTY BOUNDARY

<	NOT DETECTED ABOVE THE LABORATORY REPORTING LIMIT
ft bgs	FEET BELOW GROUND SURFACE
U	COMPOUND WAS ANALYZED FOR BUT NOT DETECTED. THE ASSOCIATED VALUE IS THE COMPOUND QUANTITATION LIMIT.
BASE	BASEMENT SCENARIO
NR	NONRESIDENTIAL
RES	RESIDENTIAL
SI	SCREENED INTERVAL
SOG	SLAB-ON-GRADE SCENARIO
SSVIAC	SITE-SPECIFIC VOLATILIZATION TO INDOOR AIR CRITERIA
VOCs	VOLATILE ORGANIC COMPOUNDS
<50k	LESS THAN 50,000 SQUARE FEET

NOTES:

1. ALL CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER LITER (µg/L)

2. DUPLICATE ANALYTICAL RESULTS ARE PRESENTED IN BRACKETS

3. CRITERIA LISTED ARE FROM THE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY (EGLE) CLEAN UP CRITERIA REQUIREMENTS TABLE 1: GROUNDWATER: RESIDENTIAL AND NONRESIDENTIAL, PART 201 GENERIC CLEANUP CRITERIA AND SCREENING LEVELS, OCTOBER 12, 2023.

4. CRITERIA LISTED ARE FROM THE EGLE JOSLYN SITE-SPECIFIC CRITERIA EVALUATION DATED MAY 3, 2022.

RACER TRUST
PONTIAC NORTH CAMPUS
PONTIAC, MICHIGAN

JOSLYN SOUTH PARCEL 2025 GROUNDWATER ANALYTICAL RESULTS

ARCADIS

FIGURE
2

CITY: NOVI, MI DIV: ENV DB: TRY PIC: J. Barrett PM: T. Linder TM: L. Crisp TR: PROJECT NUMBER: 30214041 PLOTTED: 4/7/2026 1:53 PM BY: TYarbrough
D:\GIS\Project Files\MotorsLiquidationCompany\PontiacNorthCampus\Documents\JoslynProperty\JoslynProperty_SouthParcel_AnnualAnalyticalResults.aprx
PontiacNorthCampus\JoslynProperty_SouthParcel_AnnualAnalyticalResultsJoslynProperty_SouthParcel_AnnualAnalyticalResults.aprx

Service Layer Credits: Google: © OpenStreetMap (and) contributors, CC-BY-SA Google
Earth Pro Aerial Dated March 19, 2024

JS-MW-03
JS-MW-07
JS-MW-16
JS-MW-27
JS-MW-09
JS-MW-19
JS-MW-04
JS-MW-10
JS-MW-05
JS-MW-11
JS-MW-06
JS-MW-20
JS-MW-29
JS-MW-21
JS-MW-22
6", ~5.5 ft. bgs
Lenox Ave
12", ~7 ft. bgs
12", ~8 ft. bgs
JS-MW-23
JS-MW-24
JS-MW-25
JS-MW-28
JS-MW-26
JS-MW-30

LEGEND

- EXISTING MONITORING WELL
- NO SIGNIFICANT TREND OBSERVED
- DECREASING TREND OBSERVED
- WATER
- GAS
- TELECOMMUNICATIONS
- STORM SEWER
- SANITARY SEWER
- HISTORIC SITE STRUCTURES
- PROPERTY BOUNDARY

ft bgs - FEET BELOW GROUND SURFACE

EGLE - MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

NOTES:

1. MANN-KENDALL TREND ANALYSIS CONDUCTED WHEN AT LEAST FIVE SAMPLES AND 50% DETECTED VALUES ARE AVAILABLE FOR BENZENE, ETHYLBENZENE, OR 1,2-DICHLOROETHANE.

2. ANALYTICAL DATA AVAILABLE IN TABLE 1, TREND RESULTS SUMMARIZED IN ATTACHMENT 4.

0 20 40
SCALE IN FEET

RACER TRUST
PONTIAC NORTH CAMPUS
PONTIAC, MICHIGAN

JOSLYN SOUTH PARCEL GROUNDWATER TREND ANALYSIS

ARCADIS

FIGURE
3

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Service Layer Credits: Google: © OpenStreetMap (and) contributors, CC-BY-SA Google
Earth Pro Aerial Dated March 19, 2021

JS-MW-03
JS-MW-07
JS-MW-16
JS-MW-27
JS-MW-09
JS-MW-19
JS-MW-04
JS-MW-10
1,2-DCA - INCREASING TREND
BENZENE - NO SIGNIFICANT TREND
JS-MW-05
JS-MW-11
JS-MW-06
JS-MW-20
JS-MW-29
JS-MW-21
JS-MW-22
6", ~5.5 ft. bgs
Lenox Ave
12", ~7 ft. bgs
12", ~8 ft. bgs
JS-MW-23
JS-MW-24
JS-MW-25
JS-MW-28
JS-MW-26
JS-MW-30

LEGEND

- PROPOSED SOIL VAPOR MONITORING POINT LOCATION
- EXISTING MONITORING WELL
- WATER
- GAS
- TELECOMMUNICATIONS
- STORM SEWER
- SANITARY SEWER
- HISTORIC SITE STRUCTURES
- PROPERTY BOUNDARY

ft bgs - FEET BELOW GROUND SURFACE

0 20 40
SCALE IN FEET

RACER TRUST
PONTIAC NORTH CAMPUS
PONTIAC, MICHIGAN

JOSLYN SOUTH PARCEL PROPOSED SOIL VAPOR MONITORING POINT LOCATION

ARCADIS

FIGURE
4

D:\GIS\Project Files\MotorsLiquidationCompany\PontiacNorthCampus\Documents\JoslynPropertyLenoxProperty_MonitoringPlan_2023\LenoxProperty_MonitoringPlan_2025.aprx PLOTTED: 3/24/2026 8:14 PM BY: TYarbrough

Attachment 1

Groundwater Sampling Logs

Groundwater Sampling Form

Location ID:	JS-MW-06	**Date(s):**	2025-09-10	**Work Order(s):**			Fiero Semi-Annual Sampling Event and Joslyn GWS Sampling
Client:	RACER	**Facility:**	Pontiac North Campus	**Facility Location:**	200 East Montcalm Street, Pontiac, MI, 48342, US	**Area:**	Default Site
Weather(°F):	CLEAR, T:74.59 °F, rH:46%, Clouds: 0%, Wind:0mph N			**Field Technician:**		Jeremy Myers	
Measuring Pt. Description:	Top of Inner Casing	**Screen Setting (ft-bgs):**	9.00-14.00	**Casing Diameter (in):**	2.00	**Well Casing Material:**	
Static Water Level (ft-bmp):	12.44	**Total Depth (ft-bmp):**	13.92	**Water Column(ft):**	1.48	**Gallons in Well:**	0.24
Depth to Product (ft-bmp):	NA	**Pump Intake Depth(ft-bmp):**	14.9	**Purge Method:**	Low Flow	**Purging Equipment:**	Peristaltic Pump
Purge Start Time:	14:06	**Total Volume Purged (gallons):**	0.449	**Sample ID:**	JS-MW-06_GW-091025	**Sample Time:**	15:40
Purge End Time:	15:45	**Well Volumes Purged (total):**	1.87	**Replicate Type / Replicate ID:**	NA / NA	**Water Quality Meter/ ID:**	YSI 600 XLM Sonde 1.65 inch / NA
Scope of work completed?	Yes						

Time	Total Elapsed (min)	Flow Rate	Flow Rate Unit	Depth to Water (ft)	pH (S.U.)	Specific Conductivity (mS/cm^c)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (°C)	Redox (mV)	Appearance	
											Color	Odor
14:08	0	100	mL/min	12.75	7.11	1.31	51	1.46	17.9	-5	Clear	No Odor
14:13	5	100	mL/min	12.98	7.19	1.29	35.3	2.43	16.8	-26.5	Clear	No Odor
14:18	10	100	mL/min	13.22	7.13	1.35	24.8	1.99	18.3	-24.1	Clear	No Odor
14:23	15	100	mL/min	13.74	7.08	1.32	21.1	1.18	17.6	-21.7	Clear	No Odor

Constituent Sampled	Container	Number	Volume	Preservative
Full list VOCs	Clear Glass	3	40 mL	HCl

Comments: Well ran dry @14:45
Sampled @ 15:40

Well Information:

Well Labeled Properly:	yes
Is Well in Good Condition?	good
Well Inspection Comments:	NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Groundwater Sampling Form

Location ID:	JS-MW-16	**Date(s):**	2025-09-10	**Work Order(s):**			Fiero Semi-Annual Sampling Event and Joslyn GWS Sampling
Client:	RACER	**Facility:**	Pontiac North Campus	**Facility Location:**	200 East Montcalm Street, Pontiac, MI, 48342, US	**Area:**	Default Site
Weather(°F):	CLOUDS, T:73.89 °F, rH:50%, Clouds: 75%, Wind:2.3mph N			**Field Technician:**		Lottie Jay	
Measuring Pt. Description:	Top of Inner Casing	**Screen Setting (ft-bgs):**	11.00-16.00	**Casing Diameter (in):**	2.00	**Well Casing Material:**	NA
Static Water Level (ft-bmp):	12.88	**Total Depth (ft-bmp):**	15.86	**Water Column(ft):**	2.98	**Gallons in Well:**	0.49
Depth to Product (ft-bmp):	NA	**Pump Intake Depth(ft-bmp):**	14.9	**Purge Method:**	Low Flow	**Purging Equipment:**	Peristaltic Pump
Purge Start Time:	12:48	**Total Volume Purged (gallons):**	1.875	**Sample ID:**	JS-MW-16_GW-091025	**Sample Time:**	13:45
Purge End Time:	13:48	**Well Volumes Purged (total):**	3.83	**Replicate Type / Replicate ID:**	NA / NA	**Water Quality Meter/ ID:**	YSI 600 XLM Sonde 1.65 inch / NA
Scope of work completed?	Yes						

Time	Total Elapsed (min)	Flow Rate	Flow Rate Unit	Depth to Water (ft)	pH (S.U.)	Specific Conductivity (mS/cm^c)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (°C)	Redox (mV)	Appearance	
											Color	Odor
12:49	0	180	mL/min	12.98	6.93	0.79	22.1	0.35	15.8	0.5	Clear	Strong
12:54	5	160	mL/min	13.18	6.97	0.78	30.8	0.26	16.3	-30.3	Clear	Strong
12:59	10	140	mL/min	13.32	6.99	0.78	35.9	0.47	16.8	-63.6	Clear	Strong
13:04	15	120	mL/min	13.43	6.99	0.78	34.8	0.29	17.6	-94.3	Clear	Strong
13:09	20	120	mL/min	13.55	6.99	0.78	26.1	0.24	16.9	-110.3	Clear	Strong
13:14	25	120	mL/min	13.67	6.99	0.78	22.6	0.51	16.6	-118.1	Clear	Strong
13:19	30	120	mL/min	13.84	6.99	0.78	16.1	0.21	16.2	-123.2	Clear	No Odor
13:24	35	120	mL/min	13.96	6.99	0.78	17.9	0.18	16.9	-128	Clear	Strong
13:29	40	120	mL/min	14.06	6.99	0.78	14.3	0.24	16.9	-130.8	Clear	Strong
13:34	45	120	mL/min	14.11	6.99	0.78	8.81	0.23	16.8	-131.8	Clear	Strong
13:39	50	120	mL/min	14.21	7	0.78	8.73	0.2	16.6	-133.2	Clear	No Odor
13:44	55	120	mL/min	14.27	7	0.77	8.14	0.17	16.8	-133.9	Clear	No Odor

Constituent Sampled	Container	Number	Volume	Preservative
Full list VOCs	Clear Glass	3	40 mL	HCl

Comments: None

Well Information:

Well Labeled Properly: NA

Is Well in Good Condition? NA

Well Inspection Comments: NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Description: NA

Description: NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Groundwater Sampling Form

Location ID:	JS-MW-19	**Date(s):**	2025-09-10	**Work Order(s):**			Fiero Semi-Annual Sampling Event and Joslyn GWS Sampling
Client:	RACER	**Facility:**	Pontiac North Campus	**Facility Location:**	200 East Montcalm Street, Pontiac, MI, 48342, US	**Area:**	Default Site
Weather(°F):	CLOUDS, T:75.24 °F, rH:44%, Clouds: 75%, Wind:5.75mph W-SW			**Field Technician:**		Lottie Jay	
Measuring Pt. Description:	Top of Inner Casing	**Screen Setting (ft-bgs):**	12.00-17.00	**Casing Diameter (in):**	2.00	**Well Casing Material:**	NA
Static Water Level (ft-bmp):	12.27	**Total Depth (ft-bmp):**	16.69	**Water Column(ft):**	4.42	**Gallons in Well:**	0.72
Depth to Product (ft-bmp):	NA	**Pump Intake Depth(ft-bmp):**	15.74	**Purge Method:**	Low Flow	**Purging Equipment:**	Peristaltic Pump
Purge Start Time:	14:51	**Total Volume Purged (gallons):**	1.522	**Sample ID:**	JS-MW-19_GW-091025	**Sample Time:**	15:32
Purge End Time:	15:34	**Well Volumes Purged (total):**	2.11	**Replicate Type / Replicate ID:**	NA / NA	**Water Quality Meter/ ID:**	YSI 600 XLM Sonde 1.65 inch / NA
Scope of work completed?	Yes						

Time	Total Elapsed (min)	Flow Rate	Flow Rate Unit	Depth to Water (ft)	pH (S.U.)	Specific Conductivity (mS/cm°)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (°C)	Redox (mV)	Appearance	
											Color	Odor
14:52	0	160	mL/min	12.38	7.03	1.14	58.2	0.48	16.6	37.7	Clear	No Odor
14:57	5	140	mL/min	12.43	7.09	1.14	38.2	0.63	16.3	22.4	Clear	No Odor
15:02	10	140	mL/min	12.46	7.11	1.14	28.7	0.95	16.6	16.8	Clear	No Odor
15:07	15	140	mL/min	12.46	7.11	1.14	22.5	0.86	17	14	Clear	No Odor
15:12	20	140	mL/min	12.46	7.11	1.14	15.7	0.66	17.4	8.6	Clear	No Odor
15:17	25	140	mL/min	12.46	7.1	1.14	10.6	0.46	16.9	4.4	Clear	No Odor
15:22	30	140	mL/min	12.46	7.1	1.14	6.12	0.42	17	0.6	Clear	No Odor
15:27	35	140	mL/min	12.46	7.09	1.14	5.31	0.37	17.1	-4.9	Clear	No Odor
15:32	40	140	mL/min	26.46	7.09	1.14	4.72	0.48	17.1	-7.8	Clear	No Odor

Constituent Sampled	Container	Number	Volume	Preservative
Full list VOCs	Clear Glass	3	40 mL	HCl

Comments: None

Well Information:

Well Labeled Properly: NA

Is Well in Good Condition? NA

Well Inspection Comments: NA

Description: NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Description: NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Groundwater Sampling Form

Location ID:	JS-MW-16	**Date(s):**	2025-12-11	**Work Order(s):**		Joslyn 4Q Resample and Gauging	
Client:	RACER	**Facility:**	Pontiac North Campus	**Facility Location:**	200 East Montcalm Street, Pontiac, MI, 48342, US	**Area:**	Default Site
Weather(°F):	CLOUDS, T:26.13 °F, rH:71%, Clouds: 100%, Wind:17.27mph W			**Field Technician:**		Lottie Jay	
Measuring Pt. Description:	Top of Inner Casing	**Screen Setting (ft-bgs):**	11.00-16.00	**Casing Diameter (in):**	2.00	**Well Casing Material:**	NA
Static Water Level (ft-bmp):	13.7	**Total Depth (ft-bmp):**	15.86	**Water Column(ft):**	2.16	**Gallons in Well:**	0.35
Depth to Product (ft-bmp):	NA	**Pump Intake Depth(ft-bmp):**	15.25	**Purge Method:**	Low Flow	**Purging Equipment:**	Peristaltic Pump
Purge Start Time:	13:18	**Total Volume Purged (gallons):**	1.724	**Sample ID:**	JS-MW-16_GW-121125	**Sample Time:**	14:16
Purge End Time:	14:21	**Well Volumes Purged (total):**	4.93	**Replicate Type / Replicate ID:**	**Duplicate** / DUP-01_GW-121125	**Water Quality Meter/ ID:**	Not Applicable / NA
Scope of work completed?	Yes						

Time	Total Elapsed (min)	Flow Rate	Flow Rate Unit	Depth to Water (ft)	pH (S.U.)	Specific Conductivity (mS/cm^c)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (°C)	Redox (mV)	Appearance	
											Color	Odor
13:20	0	160	mL/min	13.90	6.67	0.89	117	1.48	9.5	75.9	cloudy	Strong
13:25	5	160	mL/min	14.08	7.02	0.86	133	0.46	7.9	-18.6	cloudy	Strong
13:30	10	120	mL/min	14.20	7.03	0.83	72.8	0.65	8.9	-47.5	Clear	No Odor
13:35	15	120	mL/min	14.36	7.03	0.83	17.1	0.55	9.1	-62.2	Clear	Strong
13:40	20	120	mL/min	14.45	7.03	0.84	22.3	0.19	7.8	-70.3	Clear	No Odor
13:45	25	120	mL/min	14.60	7.05	0.83	14.7	0.17	8.9	-76.9	Clear	Strong
13:50	30	100	mL/min	14.73	7.05	0.82	18.9	0.15	8.5	-80.3	Clear	Strong
13:55	35	100	mL/min	14.82	7.06	0.83	14.4	0.15	8.3	-83.2	Clear	Strong
14:00	40	100	mL/min	14.90	7.07	0.83	10.9	0.12	8.4	-87.2	Clear	No Odor
14:05	45	100	mL/min	15.02	7.08	0.83	9.83	0.12	8.6	-92.5	Clear	Strong
14:10	50	100	mL/min	15.08	7.05	0.83	9.21	0.14	8.8	-92	Clear	Strong
14:15	55	100	mL/min	15.18	7.05	0.84	9.06	0.16	8.6	-92.3	Clear	Strong

Constituent Sampled	Container	Number	Volume	Preservative
Full list VOCs	Clear Glass	6	40 mL	HCl

Comments: None

Well Information:

Well Labeled Properly: NA

Is Well in Good Condition? NA

Well Inspection Comments: NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Description: NA

Description: NA

ft-bmp = feet below measuring point
in = inches
ft = feet
mL/min = milliliters per minute
uS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Unit
mg/L = milligrams per liter
S.U = standard units
mS/cm = milli

Attachment 2

Arcadis Technical Guidance Instructions

TGI – Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells

Rev: 3

Rev Date: April 5, 2023

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	October 12, 2018	All	Updated and re-written as TGI with new branding and content	Marc Killingstad
	1	May 8, 2020	Pages 5, 10-11	Added clarification/details for equipment requirements and procedure steps based on USEPA guidance	Marc Killingstad
	2	April 5, 2022	All	Updated to new branding template and minor edits	Marc Killingstad
	3	April 5, 2023	All	Annual review completed by SME. Document version number and document date updated.	Marc Killingstad

Approval Signatures

Prepared by:	Xuan Xu	4/5/2023
	Xuan Xu (Preparer)	Date
Reviewed by:		4/5/2023
	Marc Killingstad (Subject Matter Expert)	Date

1 Introduction

Groundwater samples are collected from monitoring wells to evaluate groundwater quality. The protocol presented in this Technical Guidance Instruction (TGI) describes the procedures to purge monitoring wells and collect groundwater samples using the low flow purging/sampling methodology. This protocol has been developed in accordance with the United States Environmental Protection Agency (USEPA) Region I *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells* (EQASOP-GW4; September 19, 2017).

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. Project teams will evaluate the last time the monitoring wells were developed and determine if additional development might be necessary. Water samples will not be taken immediately following well development. Sufficient time will be allowed for the groundwater flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well

construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

4 Personnel Qualifications

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations,such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, the groundwater sampling team will review and be thoroughly familiar withrelevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the groundwater sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

5 Equipment List

Specific to this activity, the following materials (or equivalent) will be used:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP) that includes site map, well construction records, sampling plan (sample analyses, sample volume required, and sample holding time), and prior groundwater sampling records (if available)
- Field notebook and/or smart device (phone or tablet)
- Low-flow sampling field forms (**Attachment A**)
- Appropriate personal protective equipment (PPE) (e.g., latex or nitrile gloves, safety glasses, etc.)as specified in the HASP
- Well keys and other tools to remove manhole covers (manual torque wrench with 9/16” socket and flat head screwdriver typical)
- Photoionization detector (PID) or Flame ionization detector (FID) (as appropriate, depending onsite-specific constituents of concern)
- Electronic water-level indicator (e.g., Solinist Model 101) or oil/water interface probe with 0.01- foot accuracy (oil/water as appropriate, note that sampling will not be performed when sheen orlight non-aqueous phase liquid [LNAPL] is present)
- Down-hole multi-parameter water-quality sonde (temperature/pH/specific conductivity/oxidationreduction [ORP]/turbidity/dissolved oxygen) meter coupled with flow-through-cell for measurements, for example:

  - YSI 6-Series Multi-Parameter Instrument
  - Horiba U-22 Multi-Parameter Instrument.
  - Hydrolab Series 3 or Series 4a Multiprobe and Display.

  NOTE: *Transparent, small volume flow-through-cells (e.g., 250 milliliters or less) are preferred as they allow for easy detection of air bubbles and sediment buildup in the cell, which can interfere with the monitoring instrument probes. A small volume cell also allows for quick turnover of water in the cell between measurements of the indicator field parameters. It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.*

- Plastic sheeting (e.g., Weatherall Visqueen) to protect all down-hole sampling equipment from contact with potential sources of contamination.
- Decontamination equipment
  - Non-phosphate laboratory soap (Alconox or equivalent), brushes, and clean buckets, and/or clean wash tubs—new buckets or tubs will be purchased if it cannot be determined if the present items are clean
  - Distilled or de-ionized water for equipment decontamination
- Indelible ink pen
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement)
- Sampling pump, which may consist of one or more of the following:
  - Submersible pump (e.g., Grundfos Redi-Flo 2)
  - Peristaltic pump (e.g., ISCO Model 150)
  - Bladder pump (e.g., Marschalk System 1, QED Micropurge, Geotech)
- Appropriate controller and power source for pump:
  - Submersible and peristaltic pumps require electric power from either a generator or a deep cell battery
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N_2 or CO_2 gas cylinders)
- Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used
  - For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will be used through the pump apparatus
  - Teflon® will not be used when sampling for per- and polyfluoroalkyl substances (PFAS)
- Graduated cylinder and stopwatch or other device to measure time to determine pumping rate
- Appropriate water sample containers (supplied by the laboratory)
- Appropriate blanks (trip blank supplied by the laboratory)
- Sample labels and Chain-of-Custody forms (COC)
- 0.45-micron disposable filters (if field filtering is required)

- A supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020) may be required for specific projects and will be specified in the project FIP/ work plan and the kick-off notes.
    - If used, in-line 'T' and valve allows for collection of water for turbidity measurements before the pump discharge enters the flow-through cell

NOTE: *The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.*

6 Cautions

Different USEPA regions and/or state regulatory agencies may stipulate deviations from this document. Itis the responsibility of the Project Team (Project Manager and Technical Lead) to be fully aware of the requirements from the applicable regulatory framework.

Weather

- If heavy precipitation occurs, and no cover over the sampling area and monitoring well can be erected, sampling may be discontinued until adequate cover is provided. Rainwater could compromise groundwater samples.
- Avoid extreme weather situations. Be aware that thermal currents and vertical mixing of cold and warm water inside the well casing could create a convection cell within the well and compromise data collection (e.g., biological mechanisms).
    - Direct sunlight and hot ambient temperatures may cause the groundwater in the tubing orflow-through-cell to heat up and de-gas. This may result in the loss of volatile organic compounds (VOCs) and dissolved gases. Shade the equipment from direct sunlight, keep the tubing as short as possible and avoid the hottest times of the day.
    - Sampling during freezing conditions may adversely impact the data quality objectives. USEPA recommends low-flow sampling be conducted at air temperatures above 32°F (0°C) or taking special precautions to prevent groundwater from freezing in the equipment.

Cross-Contamination

- To mitigate potential cross-contamination, groundwater samples are to be collected in a pre- determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, collect samples in order of up-gradient, then furthest down-gradient tosource area locations.
- Note that permanent markers could introduce volatile constituents into the samples*; therefore, indelible ink is recommended* to be used for labels on sample containers or sample coolers.
- When using a gasoline generator, this power source will be set-up at least 30 feet downwind from the well to avoid exhaust fumes to contaminate samples.

Pumps

- Preferred methods of extracting groundwater are adjustable rate, submersible pumps - such as centrifugal pumps or bladder pumps – constructed of stainless steel or polytetrafluoroethylene (PTFE, i.e., Teflon®). However, *PTFE will not be used when sampling for per- and polyfluoroalkyl substances (PFAS). PTFE could contain PFAS*.

- When using a bladder pump for collecting VOCs and dissolved gases, “best practice” is to set-up the pump to deliver sufficient water to fill a 40 mL VOC vial.
- The use of peristaltic pumps will be based on the type of data to be collected. *Because the use a peristaltic pump can result in de-gassing of VOC and / or dissolved gases from groundwater, a different type of pump will be considered if these compounds are of concern.*
- *Manual or motor driven inertial pumping devices are not recommended because they cause greater disturbance during purging and pumping than regular pumps and are less easily controlled. This could cause a higher degree of data variability.*

Tubing

- When sampling for VOCs, SVOCs, pesticides, PCBs and inorganics, use of PTFE (Teflon®) or PTFE-lined tubing is preferred. However, PTFE tubing will not be used when sampling for PFAS.
- PVC, polypropylene or polyethelene tubing may be used when sampling for metals or other inorganics.
- Tubing with inside diameters of 1/4 or 3/8 inch is recommended because this will help ensure tubing remains water filled when operating at very low pumping rates.

General Precautions

- Store and/or stage empty and full sample containers and coolers out of direct sunlight.
- It may be necessary to field filter the groundwater for some parameters (e.g., metals) during collection, depending on preservation, analytical method, and project quality objectives. The task-kick-off notes and the FIP/work plan will list the samples that require field filtering.
- Be careful not to overtighten lids with Teflon® liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon® seal.

7 Health and Safety Considerations

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be always worn in line with the task and the site-specific HASP.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife)—open well caps slowly and keep face and body away to allow to vent any built-up pressure; only use non-toxic peppermint oil spray for stinging insect nests; review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives, and use appropriate hand protection.

Generators and cord and plug equipment will employ an overcurrent protection device such as an integrated ground fault circuit interrupter (GFCI) cord. Grundfos pump controllers will not run properly with a GFCI, so the power source will be equipped with other overcurrent protection means.

Overtightening of lids with Teflon® liners can cause the glass to shatter and create a risk for hand injuries.

8 Procedure

Field personnel will set up and perform low-flow sampling in accordance with the following procedures.

1. Review FIP and groundwater sampling records from previous sampling events (if available) prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for each well to perform sampling as efficiently as possible (i.e., reach a stabilized pumping condition).
2. Calibrate field instruments according to manufacturer procedures for calibration and record calibration procedure and results in field log.
3. All equipment will either be new or decontaminated in accordance with appropriate guidance document *(TGI – Groundwater and Soil Sampling Equipment Decontamination)* prior to use.
4. Visually inspect the well to ensure that it is undamaged, properly labeled and secured
   a. Damage or other conditions that may affect the integrity of the well will be recorded in the Field Activity Daily Log and brought to the attention of the designated Field Manager and/or Project Manager
   b. Record well construction and conditions on the Low-Flow Sampling Field Form **(Attachment A)**.
5. Place clean plastic sheeting on the ground near the well to keep monitoring and sampling equipment off the surface unless the equipment is elevated above the ground (e.g., on a table).
6. Open the well cover while standing upwind of the well. Remove the well cap and place it on the plastic sheeting. If appropriate or required for site-specific conditions, insert the photoionization detector (PID) probe approximately 4 to 6 inches into the casing or the well headspace and cover it with a gloved hand. Record the PID reading in the field log. Perform air monitoring in the breathing zone according to the HASP and/or JSA.
7. Measure and record the initial depth to groundwater prior to placing the pumps.
8. Prepare and install the pump in the well.

   NOTE: *Groundwater will be purged from the wells using an appropriate pump. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet below ground surface), a submersible or bladder pump will be used, provided that the well is constructed with a casing diameter of at least two (2) inches (the minimum well diameter capable of accommodating such pumps). For smaller diameter wells, where the depth to water is below the sampling range of a peristaltic pump, alternative sampling methods (i.e., bailing or small diameter bladder pumps) will be used to purge and sample the groundwater. Bladder pumps are preferred over peristaltic and submersible pumps to prevent volatilization if sampling of VOCs and/or dissolved gasses is required. Purge water will be collected and containerized according to the direction of the project team.*

   a. For submersible and non-dedicated bladder pumps, decontaminate the pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new bladder and attachment of an air-line, sample discharge line, and safety cable prior to placement in the well. Attach the air-line tubing to the air-port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Take care not to reverse the air and discharge tubing lines during bladder pump setup, as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of pump (if present, depending on pump model used). Slowly lower the pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Avoid twisting

and tangling of safety cable, tubing, and electrical lines while lowering the pump into the well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well, as this could lead to unintended contamination.

b. If using a bladder pump, connect the air-line to the pump controller output port. The pump controller will be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon® tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Turn on the pump controller power (if an on/off switch is present) and verify that all batteries are charged and fully functioning before starting the pump.

c. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least two (2) feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

d. If using an in-line 'T' and valve, install between pump discharge water line and the bottom inlet port of the flow-through cell. Attach a short piece of tubing to the outlet. This set-up will be used to collect samples for turbidity readings.

9. Connect the pump discharge water line to the bottom inlet port on the flow-through cell connected to the multi-parameter water-quality sonde and make sure to record equipment/instrument identification (manufacturer and model number).

10. Before starting the pump, ensure that the water level inside the well has stabilized (i.e., measure the water level multiple times after deploying the pump in the well).

11. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified) and adjust the pumping rate to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement): the water level should stabilize, however, this is not always possible.

12. If the well diameter is of sufficient size, measure the water level every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping.

13. Maintain a steady flow rate to the extent practicable and do not break pump suction or cause entrainment of air in the sample.

14. Record pumping rate adjustments and depths to water.

    If necessary, reduce pumping rates to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters; if the recharge rate of the well is very low, use alternative purging techniques, which will vary based on the well construction and screen position.

    For wells screened across the water table, the well may be pumped dry, and sampling can commence as soon as the volume in the well has recovered sufficiently to permit collection of samples.

    For wells screened entirely below the water table, the well can be pumped until a stabilized level (which may be greater than the maximum displacement goal of 0.3 feet) is maintained and monitoring for stabilization of field indicator parameters can commence; if a lower stabilization level cannot be

maintained, the well may be pumped until the drawdown is at a level slightly higher than top of the well screen.

15. After water levels have stabilized and a sufficient volume has been purged (see note below), continue pumping and begin monitoring field indicator parameters using a multi-parameter water-quality sonde coupled with a flow-through-cell.

    NOTE: *The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.*

16. Use the flow to measure all indicator field parameters, except for turbidity, every 3 to 5 minutes (or after each volume of the flow-through cell has been purged or other appropriate interval); turbidity samples will be collected before the flow-through-cell using the T-valve and a clean container such as a glass beaker.

17. Record field indicator parameters on the groundwater sampling log.

18. The well is considered stabilized and ready for sample collection when three consecutive readings are within the following limits:

    - **Turbidity** within ± 10% for values greater than 5 nephelometric turbidity units [NTUs] or if three turbidity values are less than 5 NTUs, consider the values stabilized
    - **Dissolved Oxygen (DO)** within ± 10% for values greater than 0.5 mg/L or if three DO values are less than 0.5 mg/L, consider the values stabilized
    - **Specific Conductance** within ± 3%
    - **Temperature** within ± 3%
    - **pH** within ± 0.1 unit
    - **Oxidation/Reduction Potential (ORP)** within ±10 millivolts (mV)

    NOTE: *Alternate stabilization goals may exist in different geographic regions, consult the site- specific FIP/work plan for stabilization criteria).*

    NOTE: *While achieving turbidity levels less than 5 NTU and a stable drawdown of less than 0.3 feet is desirable, sample collection may still take place provided the indicator field parameter criteria in this procedure are met.*

19. If the parameters have stabilized but turbidity remains relatively high (e.g., greater than 50 NTUs), the pump flow rate may be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible. If groundwater turbidity has been minimized (i.e., consecutive readings within ± 10%) and the values for all other parameters have stabilized, the well may be sampled; however, consult specifications in the FIP/work plan and/or the project technical lead prior to sampling.

20. If after one (1) hour of purging indicator field parameters have not stabilized, consult specifications in the FIP/work plan and/or the project technical lead prior to sampling.

    In general, three potential options are available if stabilization criteria are not met:

    a. Continue purging until stabilization is achieved.

    b. Discontinue purging, do not collect any samples, and record in field logbook/on the sampling form that stabilization could not be achieved (documentation must describe attempts to achieve stabilization).

c. Discontinue purging, collect samples, and provide full explanation of attempts to achieve stabilization. There is a risk that the analytical data obtained under these conditions, particularly metals and hydrophobic organic analytes, may reflect a sampling bias and, as a result, the data may not meet the data quality objectives of the sampling event.

NOTE: *DO is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); therefore, great care will be taken to minimize the agitation or other disturbance of water within the flow-through cell while collecting these measurements. If air bubbles are present on the DO probe or in the discharge tubing, remove them before taking a measurement. If DO values are not within acceptable range for the temperature of groundwater, again check for and remove air bubbles on the probe before re-measuring. The table below may be used as a general guide for DO values under various temperatures; however, understand that the table corresponds to freshwater solubility and groundwater contaminants may affect oxygen solubility. If DO value is 0.00 or less, then the meter will be serviced and re-calibrated. If DO values are above possible results, then the meter will be serviced and re-calibrated.*

NOTE: *During extreme weather conditions, stabilization of field indicator parameters may be difficult to attain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field logbook/on the sampling form.*

NOTE: *If other field conditions are suspected of preventing stabilization of certain parameters, detailed observations will be documented in the field logbook/on the sampling form.*

Oxygen Solubility in Fresh Water

Temperature (degrees C)	Dissolved Oxygen (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., Introduction to Environmental Engineering, PWS Publishing Company, Boston, 468 pages (1996)

21. Complete the sample label(s) and cover the label(s) with clear packing tape to secure the label onto the container.
22. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container.
    a. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell will be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection.
    b. Under no circumstances will analytical samples be collected from the discharge of the flow- through cell.
    c. If an in-line ‘T’ and valve are used, the valve needs to be removed as well.

d. Samples will be collected in the following order: VOCs, total organic carbon (TOC), semi- volatile organic compounds (SVOCs), metals and cyanide, and others (or other order as defined in the site-specific FIP/work plan).
e. When the container is full, tightly screw on the cap.

23. If sampling for total and filtered metals and/or polychlorinated biphenyls (PCBs), a filtered and unfiltered sample will be collected.
    a. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected.
    b. Continue to run the pump until an initial volume of "flush" water has been run through the filter in accordance with the manufacturer's directions (generally 100 to 300 mL).
    c. Collect the filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container.
    d. When the container is full, tightly screw on the cap.
24. Secure with packing material and store the samples on ice in an insulated transport container provided by the laboratory and include a temperature blank in each container to be shipped.
25. Record on the Low-Flow Sampling Field Form (and bound field logbook) the time at which sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging **(see Attachment A)**.
26. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump setup.
27. Slowly remove the pump, tubing, lines, and safety cable from the well.
    a. If using dedicated tubing, do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.
    b. If using dedicated tubing, it will be folded - without pinching it - to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events.
    c. Use a length of rope or string to tie the tubing to the well cap.
    d. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date, coil the tubing neatly and placed in a clean plastic bag that is clearly labeled with the well ID ensuring the bag is tightly sealed before placing it in storage.
28. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.
29. Complete the procedures for packaging, shipping, and handling with the associated Chain-of- Custody.
30. Complete decontamination for flow-through analytical cell and submersible or bladder pump, as appropriate *(TGI – Groundwater and Soil Sampling Equipment Decontamination).*
31. At the end of each day of the sampling event, perform calibration check of field instruments and record procedure and results in field log.

9 Waste Management

Materials generated during groundwater sampling activities, including disposable equipment and excess purge water, will be stored on site in appropriately labeled containers and disposed of properly. Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage*, the procedures identified in the

FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field logbook.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

Management of the original documents from the field will be completed in accordance with the site- specific QAPP.

In general, forms (e.g., Low-Flow Sampling Field Forms), logs/notes (including daily field and calibration logs), digital records, and Chain-of-Custody records will be maintained by the field team lead.

Field logs and Chain-of-Custody records will be transmitted to the Arcadis Project Manager and/or Task Manager, as appropriate, at the end of each day unless otherwise directed. Electronic data files will be sent to the project team and uploaded to the electronic project folder daily.

Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

11 Quality Assurance

Quality assurance procedures shall be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

Unless described otherwise in the project-specific FIP/work plan, QAPP, or Sampling and Analysis Plan, quality assurance/quality control samples will be collected as follows:

- One duplicate for every 10 samples
- One laboratory matrix/matrix spike sample for every 20 samples
- In addition to the quality control samples to be collected in accordance with this TGI, the following quality control procedures will be observed in the field:
- Collect samples from monitoring wells, in order of increasing concentration, to the extent known based on review of historical site information if available
- Equipment blanks will include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well)
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled

- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures—calibrate instruments at the beginning of each day, verify the calibration at the end of each day, and record all calibration activities in the field notebook
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well following the procedure for equipment decontamination

12 References

USEPA. 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (September 1986).

USEPA. 1991. *Handbook Groundwater, Volume II Methodology*, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July 1991).

USEPA Region I. 2017. *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells (*EQASOP-GW4; September 19, 2017).

U.S. Geological Survey (USGS). 1977. *National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination*. Reston, Virginia.

13 Attachments

Attachment A – Low Flow Sampling Field Form

Attachment A

Low-Flow Sampling Field Form

GROUNDWATER SAMPLING FORM

Project No. _____ Well ID _____ Date _____

Project Name/Location _____ Weather _____

Measuring Pt. Description _____ Screen Setting (ft-bmp) _____ Casing Diameter (in.) _____ Well Material ____ PVC ____ SS

Static Water Level (ft-bmp) _____ Total Depth (ft-bmp) _____ Water Column (ft) _____ Gallons in Well _____

MP Elevation _____ Pump Intake (ft-bmp) _____ Purge Method: _____ Sample Method _____

Pump On/Off _____ Centrifugal _____ Submersible _____ Other _____

Sample Time: _____ Volume Purged _____

Purge Start _____ Gallons Purged _____ Sample ID _____ Sampled by _____

Purge End _____ Replicate/Code No. _____

Time	Minutes Elapsed	Rate (gpm)/(mL/min) 200mL/min +	Depth to Water (ft) -0.3	Gallons Purged	pH ± 0.1	Cond. (µMhos)/(mS/cm) ± 3%	Turbidity (NTU) ± 10%	DO (mg/L) ± 10%	Temp. (°C)/(°F) ± 3%	Redox (mV) ± 10mV	Appearance	
											Color	Odor
Stabilization Calculations (±)												
Stabilization Criteria					**± 0.1 s.u.**	**±3%**	**± 10% or within 1 NTU (1)**	**± 10%**	**±3%**	**±10 mV**		

(1) **Turbidity** < 50 NTU and ±10% or within 1 NTU of a previous reading when <10 NTU

Constituents Sampled	Container	Number	Preservative

Comments _____

Well Casing Volumes

Gallons/Foot					
	1" = 0.04	*1.5" = 0.09*	*2.5" = 0.26*	*3.5" = 0.50*	*6" = 1.47*
	1.25" = 0.06	*2" = 0.16*	*3" = 0.37*	*4" = 0.65*	

Well Information

Well Location: _____ Well Locked at Arrival: Yes / No

Condition of Well: _____ Well Locked at Departure: Yes / No

Well Completion: Flush Mount / Stick Up Key Number To Well: _____

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TGI – Soil Description

Rev: 7

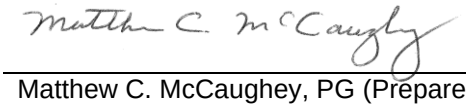
Rev Date: April 14, 2025

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	May 20, 2008	17	Original SOP	Joe Quinnan Joel Hunt
	1	September 2016	15	Updated to TGI	Nick Welty Patrick Curry
	2	February 16, 2018	15	Updated descriptions, attachments and references in text	Nick Welty Patrick Curry
	3	April 15, 2022		Minor description edits, intro of grain-size K analysis, revised boring log template	Matt McCaughey Patrick Curry
	4	June 5, 2023	All	Annual review completed by SME.	Patrick Curry
	5	June 20, 2024	All	Annual review completed/approved by Patrick Curry	Patrick Curry
	6	Mar 31, 2025	All	Annual review completed/approved by Patrick Curry	Patrick Curry
	7	April 14, 2025	All	Edits to description of plasticity	Patrick Curry

Approval Signatures

Prepared by: 4/14/2025



Matthew C. McCaughey, PG (Preparer) Date

Reviewed by: 4/14/2025

Patrick Curry, PG (Subject Matter Expert) Date

1 Introduction

This Arcadis Technical Guidance Instruction (TGI) describes proper soil description procedures based on visual inspection and testing of soil cores and samples. This document has been developed to emphasize field observation and documentation of details required to:

- Make hydrostratigraphic interpretations guided by depositional environment/geologic settings
- Provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

This TGI should be followed for unconsolidated material unless there is an established client-required specific procedure or regulatory-required specific procedure. In cases where there is a required specific procedure, it should be followed and should be referenced and/or provided as an appendix to reports that include soil classifications and/or boring logs. When following a required non-Arcadis procedure, additional information required by this TGI should be included in field notes with client approval.

This TGI incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister and Udden Wentworth. However, none of these standard systems focus specifically on contaminant hydrogeology and remedial design. Therefore, although each of these systems contain valuable guidance and information related to correct descriptions, strict application of these systems can omit information critical to our clients and the projects that we perform.

This TGI includes the following attachments:

- **Attachment A –** Field Soil Description Guide
- **Attachment B –** Particle Size System Comparison
- **Attachment C –** Description of Logging Terms
- **Attachment D –** Blank Boring Log
- **Attachment E –** Completed Boring Log

This TGI does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other Arcadis procedure, guidance, and instructional documents, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

4 Personnel Qualifications

Soil descriptions should only be performed by Arcadis personnel or authorized sub-contractors with a degree in geology or a geology-related discipline. Field personnel will complete training on the Arcadis soil description TGI in the office and/or in the field under the guidance of an experienced field geologist with at least 2 years of prior experience applying the Arcadis soil description method.

5 Equipment List

The following equipment should be taken to the field to facilitate soil descriptions:

- Field book, field forms or digital devices to record soil descriptions
- Field book for supplemental notes
- This TGI for Soil Descriptions and any project-specific procedure, guidance, and/or instructional documents (if required)
- Field card showing Wentworth scale
- Munsell® soil color chart
- Tape measure divided into tenths of a foot
- Stainless steel knife or spatula
- Hand lens
- Water squirt bottle
- 4-ounce glass jars with lids (for collecting soil core samples)
- Personal protective equipment (PPE), as required by the HASP
- Digital camera

- Folding table

6 Cautions

Drilling and drilling-related hazards including subsurface utilities are discussed in other procedure documents and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

7 Health and Safety Considerations

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

8 Procedure

8.1 General Procedures

- Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g., split-spoon or Shelby sample for hollow-stem drilling, acetate sleeves for direct push, bagged core for sonic drilling, etc.
- Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.
- Set up boring log field sheet.
    - Determine the proper units of measure. Drillers in both the US and Canada generally work in feet due to equipment specifications. Field geologists typically record drilling depths, core recovery, and sample intervals in feet and grain size in millimeters
    - Use the Arcadis standard boring log form (**Attachment D**). *Note that as of April 2022, several digital logging applications are available through the FieldNow™ program and the Fulcrum app. A future revision of this TGI, likely in early 2023, will emphasize digital logging methods and field boring log forms will no longer be acceptable. FieldNow is discussed further in Section 10.*
    - The boring log template includes a graphic log of the primary soil texture to support quick visual evaluation of grain size. The purpose of the graphic log is to quickly assess relative soil permeability. Note, for poorly sorted soils (e.g., glacial till), the principal component may not correlate to permeability of the sample. In this case, the geologist should use best judgement to graph overall soil type consistent with relative soil permeability. For example, for a dense sand/silt/clay till, the graphic log would reflect the silt/clay, rather than sand.

    - Record depths along the left-hand side at a standard scale to aid in the use of this tool.
- Examine each soil core (this is different than examining each sample selected for laboratory analysis) and record the soil conditions in accordance with guidelines provided in Section 8.2.
- At the end of the boring, record the amount of drilling fluid used (if applicable) and the total depth logged.
- At a minimum, a written or digital boring log should be prepared with the following information:
    - Describe type of surface material (asphalt, grass, topsoil, gravel, etc.)
    - Describe the type of fill or non-native soils and estimated depth to native soils
    - Record sample intervals (soil cores, environmental and/or geotechnical samples)
    - Describe soil conditions in accordance with this TGI
    - Record moisture content and estimated depth to water table or saturated zone
    - Record the total depth and document why drilling was stopped (refusal, target depth achieved, etc.)

8.2 Soil Description Procedures

The standard soil description order is presented below.

- Depth
- PRIMARY TEXTURE
- Principal and Minor Components with Descriptors
    - % Modifiers and grain size fraction
    - Angularity for very coarse sand and larger particles
    - Consistency or Density
    - Plasticity for clay and clay mixtures
    - Dilatancy for silt and silt-sand mixtures
- Sorting
- Moisture Content
- Color
- Notes

Depth. To measure and record the depth below ground surface (bgs) of top and bottom of each stratum, the following information should be recorded.

- Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.
- Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g., 36/60 for 36 inches recovered from 5-ft [60-inch] sampling interval).
- Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.
- Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 36/60 bottom 12 inches of core empty.

Determination of Components. Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot-long split-spoon where strata of coarse sand, fine sand and clay are present, then the resultant description should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: SAND, fine; with interbedded lenses of Silt and Clay, ranging between 1 and 3 inches thick.

Identify principal component and express volume estimates for minor components on logs using the following standard modifiers.

Modifier	Percent of Total Sample (by volume)
and	36 – 50
some	21 - 35
little	10 - 20
trace	<10

Determination of components is based on using the Udden-Wentworth particle size classification (see below) and measurement of the average grain size diameter. Each size class differs from the next larger class by a constant ratio of ½. Due to visual limitations, the finer classifications of Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the Soil Description Field Guide (**Attachment A**) that shows Udden-Wentworth scale or by measuring with a ruler.

The following table summarized the modified Udden-Wentworth Scale for grain size classification. Note that gravel is a size category encompassing the granule, pebble, cobble, and boulder size classes.

Udden-Wentworth Scale (Modified by Arcadis, 2008)				
Size Category	**Size Class**	**Millimeters**	**Inches**	**Standard Sieve #**
Gravel (Cobble)	Boulder	256 – 4096	10.08+	
	Large cobble	128 - 256	5.04 -10.08	
	Small cobble	64 - 128	2.52 – 5.04	
Gravel (Pebble)	Very large pebble	32 – 64	0.16 - 2.52	
	Large pebble	16 – 32	0.63 – 1.26	
	Medium pebble	8 – 16	0.31 – 0.63	
	Small pebble	4 – 8	0.16 – 0.31	No. 5 +
	Granule	2 – 4	0.08 – 0.16	No.5 – No.10

Sand	Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
	Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
	Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
	Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
	Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Fines	Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
	Clay (subgroups not included	1/2048 – 1/256	0.00002 – 0.0002	

Identify components as follows. Remove particles greater than very large pebbles (64-mm diameter) from the soil sample. Record the volume estimate of the greater than very large pebbles. Examine the sample fraction of very large pebbles and smaller particles and estimate the volume percentage of the pebbles, granules, sand, silt and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category.

Sieve and hydrometer grain-size analysis can be used to vet the visual description, as well as used to estimate hydraulic conductivity. Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. It is recommended that sieve-hydrometer analysis be performed on representative samples from each soil type to estimate the fraction of each grain size category using ASTM D422 Standard Test Method for Particle-Size Analysis of Soils. If desired sieve sizes can be specified to follow the Udden-Wentworth classification (U.S. Standard sieve sizes 6; 12; 20; 40; 70; 140; and 270) to retain pebbles; granules; very coarse sand; coarse sand; medium sand; fine sand; and very fine sand, respectively.

Several empirical formulas provide a reliable means of estimating hydraulic conductivity (K) from grain-size distribution data, provided that the formation does not contain abundant fines that result in cohesive or plastic behavior or include cobble-sized grains (Payne et al. 2008). Grain-size analysis can help bracket the permeability of hydrostratigraphic units (HSUs) and identify order-of-magnitude spatial variations in K. Arcadis has completed modifications to the Excel-based program HydroGeoSieveXL (Devlin 2015) to process sieve data quickly and estimate K. The tool calculates estimated K values from grain-size data using 15 different empirical formulas. A decision matrix then selects which of the formulas is relevant for the soil type and calculates an average K.

Principal Component. The principal component is the size fraction or range of size fractions containing the majority of the volume. Examples: the principal component in a sample that contained 55% small to medium pebbles would be “PEBBLES, small to medium”; or the principal component in a sample that was 20% fine sand, 30% medium sand and 25% coarse sand would be “SAND, fine to coarse” or for a sample that was 40% silt and 45% clay the principal component would be “CLAY and SILT”.

The boring log form (**Appendix D**) includes a graphic log to visually illustrate a relative estimate of soil permeability. To use the graphic log, place an ‘X’ or shade the appropriate column for the primary soil texture. If the soils have a high percentage of a secondary soil texture (i.e., when the ‘and’ modifier’ is used), it’s acceptable to mark off the appropriate column for the secondary soil texture in this instance. However, care should be used to avoid marking off the columns for other minor soil textures because doing so will make it difficult to determine the relative soil permeability of the poorly sorted soils.

As noted above, for poorly sorted soils such as glacial till, the principal component may not correlate to permeability of the sample. In this case, the geologist should use best judgement to graph overall soil type consistent with relative soil permeability.

Minor Component(s). The minor component(s) are the size fraction(s) containing less than 50% volume. Example: the identified components are estimated to be 60% medium sand to granules, 25% silt and clay; 15% pebbles – there are two identified minor components: silt and clay; and pebbles.

Include a standard modifier to indicate percentage of minor components (see particle size table) and the same descriptors that would be used for a principal component. An example of minor constituents with modifiers include: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

8.2.1 Secondary Descriptors

The following are the descriptors used outside of the principal and minor components. Note that plasticity should be provided as a descriptor for clay and clay mixtures. Dilatancy should be provided for silt and silt mixtures. Angularity should be provided as a descriptor for pebbles and coarse sand.

Angularity. Describe the angularity for very coarse sand and larger particles in accordance with the table below (ASTM D-2488-06). Figures showing examples of angularity are available in ASTM D-2488-06 and the Arcadis Soil Description Field Guide (**Appendix B**).

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Sub-Angular	Particles are like angular description but have rounded edges
Sub-Rounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges.

Plasticity. Describe the plasticity for clay and clay mixtures based on observations made during the following test method (ASTM D-2488-06).

- As in the dilatancy test (described below), select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material, adding water, if necessary, until it has a soft, but not sticky, consistency.
- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation. Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

Description	Criteria
Non-plastic	A 1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Dilatancy. Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D-2488-06).

- From the specimen, select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water, if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and not the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

Note that silt and silt-sand mixtures will be non-plastic and display dilatancy. Clay mixtures will have some degree of plasticity but do not typically react to dilatancy testing. Therefore, the tests outlined above can be used to differentiate between silt-dominated and clay-dominated soils.

Sorting. Sorting is the opposite of grading, which is a commonly used term in the USCS or ASTM methods to describe the uniformity of the particle size distribution in a sample. Well-sorted samples are poorly graded and poorly sorted samples are well graded. Arcadis prefers the use of sorting for particle size distributions and grading to describe particle size distribution trends in the vertical profile of a sample or hydrostratigraphic unit because of

the relationship between sorting and the energy of the depositional process. For soils with sand-sized or larger particles, sorting should be determined as follows:

Description	Criteria
Well Sorted	the range of particle sizes is limited (e.g., the sample is comprised of predominantly one or two grain sizes)
Poorly Sorted	A wide range of particle sizes are present

You can also use sieve analysis to estimate sorting from a sedimentological perspective; sorting is the statistical equivalent of standard deviation. Smaller standard deviations correspond to higher degree of sorting (see Remediation Hydraulics, 2008).

Consistency or Density. This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) obtained when using hollow-stem auger drilling methods and a split spoon sampling device. Otherwise, some field tests are available as outlined below. When drilling with hollow-stem augers and split-spoon sampling, the SPT blow counts and N-value is used to estimate density. The N-value is the blows per foot for the 6" to 18" interval. For example, for a 24-inch split spoon soil core, the recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to 12", the third interval is 12" to 18", the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal. In recent years, more common drilling methods include rotary-sonic or direct push. When blow counts are not available, density is determined using a thumb test. Note however, the thumb test only applies to fine-grained soils.

Fine-grained soil – Consistency

Description	Criteria	Blow Counts (6-12 to 12-18-inch split spoon interval)
Very soft	Easily penetrated several inches by thumb	N-value < 2
Soft	Easily penetrated one inch by thumb	N-value 2-4
Medium Stiff	Indented about ½ inch with much effort	N-value 5-8
Stiff	Indented with ¼ inch with great effort	N-value 9-15
Very Stiff	Readily indented by thumbnail	N-value 16-30
Hard	Indented by thumbnail with difficulty	N-value > than 30

Coarse-grained soil – Density

Description	Criteria	Blow Counts (6-12 to 12-18-inch split spoon interval)
Very loose	Density classification of coarse-grained soils is only required when blow counts from standard penetration tests are performed during hollow-stem auger drilling	N-value 1- 4
Loose		N-value 5-10
Medium dense		N-value 11-30
Dense		N-value 31- 50
Very dense		N-value >50

Moisture Content. Moisture content should be described for each soil sample in accordance with the table below (percentages should not be used unless determined in the laboratory). *Note that some drilling methods (e.g., sonic) can compress and dry out the sample during drilling. Therefore, it can be difficult to determine if a sample is saturated, or merely moist. In this case, care should be taken to try and determine a static water level within the borehole by measuring depth to water through the drill casing, if possible.*

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty
Moist	Damp but no visible water
Wet	Visibly free water

Color. Color should be described using simple basic terminology and modifiers based on the Munsell system. Munsell alpha-numeric codes are required for all samples. If the sample contains layers or patches of varying colors this should be noted, and all representative colors should be described. The colors should be described for moist samples. If the sample is dry, it should be wetted prior to comparing the sample to the Munsell chart.

Notes. Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- Odor - You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH “Pocket Guide to Chemical Hazards”, e.g., “pungent” or “sweet” and should not indicate specific chemicals such as “phenol-like” odor or “BTEX” odor.
- Structure
- Bedding planes (laminated, banded, geologic contacts).
- Presence of roots, root holes, organic material, man-made materials, minerals, etc.
- Mineralogy

- Cementation
- NAPL presence/characteristics, including sheen (based on client-specific guidance).
- Reaction with HCl - typically only used for special soil conditions, such as caliche environments.
- Origin, if known (Lacustrine; Fill; etc.).

8.3 Example of Soil Descriptions

The standard generic description order is presented below.

- Depth
- PRIMARY TEXTURE
- Principal and Minor Components with Descriptors
    - % Modifiers and grain size fraction
    - Angularity for very coarse sand and larger particles
    - Consistency or Density
    - Plasticity for clay or clay mixtures
    - Dilatancy for silt and silt-sand mixtures
- Sorting
- Moisture Content
- Color
- Notes

10-15 feet CLAY, trace silt, trace small to very large pebbles, subround to subangular up to 2" diameter; medium to high plasticity, stiff, moist, dark grayish brown (10YR 4/2). NOTE: Lacustrine; laminated 0.1 to 0.2" thick, laminations brownish yellow (10YR 4/3).

10 -15 feet SAND, medium to very coarse, little granules to medium pebbles, subround to subangular, trace silt; poorly sorted, wet, grayish brown (10YR5/2).

Unlike the first example where a density of cohesive soils could be estimated, this rotary-sonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose sand and pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

9 Waste Management

Project-specific requirements should be identified and followed. The following procedures, or similar waste management procedures are generally required.

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

10 Data Recording and Management

10.1 Digital Data Collection Process Overview

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

10.2 Digital Data Collection Tools for Soil Descriptions

Arcadis is transitioning from the use of paper forms to a digital soil description logging process using web-based FieldNow applications accessible on field tablets and smart phones. Company-wide roll out of a FieldNow application for soil descriptions is targeted by the end of 2022.

Paper forms are included in Revision 3 (April 2022) of this Soil Description TGI. Specifically, a blank boring log and completed boring log are provided in **Attachment D** and **Attachment E**. Additional guidance and examples of the digital data collection tools for soil descriptions will be provided in the next revision to this TGI.

10.3 Additional Guidance

The general logging scheme for soil descriptions is described in this document. Depending on project data quality objectives, specific soil description parameters that are not applicable to project goals may be omitted at the project manager's discretion. In any case, use of consistent procedures is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. Photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or logbook and a label showing this information in the photo is useful.

For projects involving soil logging and soil sampling, the soil sample should be recorded on the Arcadis boring log form and the field logbook based on Data Quality Objectives for the task/project.

11 Quality Assurance

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

12 References

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

ASTM D422, 63rd Edition, 1972 - Standard Test Method for Particle-Size Analysis of Soils.

Devlin, J.F. 2015. HydroGeoSieve XL: an Excel-based tool to estimate hydraulic conductivity from grain-size analysis. Hydrogeology Journal, DOI 10.1007/s10040-015-1255-0.

Folk, Robert L. 1980. Petrology of Sedimentary Rocks, p. 1-48.

Payne, F. C., Quinnan, J. A., & Potter, S. T. 2008. Remediation Hydraulics. Boca Raton: FL: CRC Press.

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm.

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 “Munsell® Color Soil Color Charts.

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 “Sand Grain Sizing Folder.”

NIOSH Pocket Guide to Chemical Hazards.

Attachment A

Soil Field Reference Guide

The purpose of this attachment is to present a field reference guide for use during soil logging. Field staff are encouraged to bring a laminated copy of this reference guide into the job site.

SOIL DESCRIPTION FIELD GUIDE (APRIL, 2022; REV. 3.0)

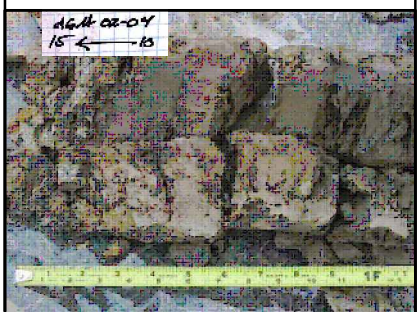
ARCADIS Design & Consultancy for natural and built assets

FINE-GRAINED SOILS

Description	Criteria
	Descriptor - Plasticity
Nonplastic	A 1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.
	Descriptor - Dilatancy
No Dilatancy	No visible change when shaken or squeezed.
Slow	Water appears slowly on the surface of soil during shaking and does not disappear or disappears slowly when squeezed.
Rapid	Water appears quickly on surface of soil during shaking and disappears quickly when squeezed.
Minor Components with Descriptors	
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Consistency
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated 1 inch by thumb.
Medium stiff	N-value 5-8 or indented about 1/2 inch by thumb with great effort.
Stiff	N-value 9-15 or indented about 1/4 inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty.
Color using Munsell	
Geologic Origin (if known)	
Other	

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10-15 feet CLAY, trace silt, trace small to very large pebbles, subround to subangular up to 2" diameter; medium to high plasticity, stiff, moist, dark grayish brown (10YR 4/2). NOTE: Lacustrine; laminated 0.1 to 0.2" thick, laminations brownish yellow (10YR 4/3).



DESCRIPTION ORDER

Depth Interval
PRIMARY TEXTURE (e.g., SAND)
Principal and Minor Components with Descriptors:
- % Modifiers and grain size fraction
- Angularity coarse sand and larger
- Consistency or Density
- Plasticity for silt and clay
- Dilatancy for silt and silt-sand

Sorting for granular sediments
Moisture Content
Color
Other NOTES

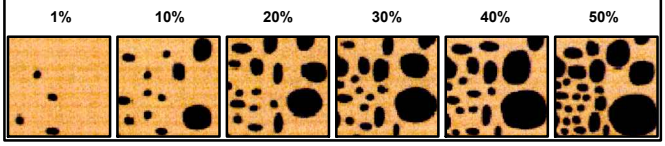
MINOR COMPONENTS % MODIFIERS

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

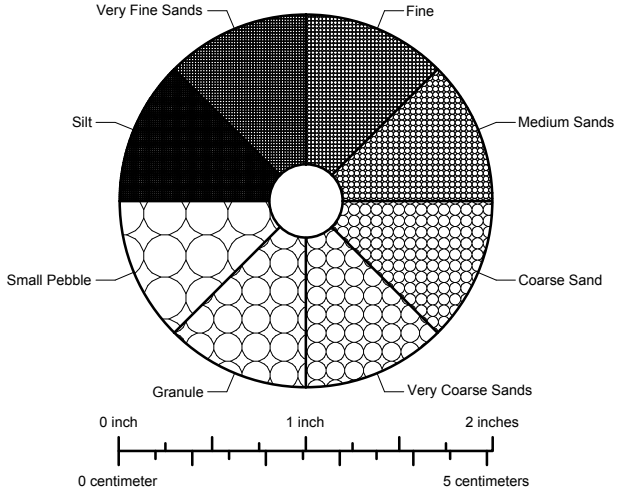
UDDEN-WENTWORTH SCALE

Fraction	Sieve Size	Grain Size	Approximate Scale
Boulder		256 - 4096 mm	Larger than volleyball
Large Cobble		128 - 256 mm	Softball to volleyball
Small Cobble		64 - 128 mm	Pool ball to softball
Very Large Pebble		32 - 64 mm	Pinball to pool ball
Large Pebble		16 - 32 mm	Dime size to pinball
Medium Pebble		8 - 16 mm	Pencil eraser to dime size
Small Pebble	No. 5+	4 - 8 mm	Pea size to pencil eraser
Granule	No. 10 - 5	2 - 4 mm	Rock salt to pea size
Very Coarse Sand	No. 18 - 10	1 - 2 mm	See field gauge card
Coarse Sand	No. 35 -18	0.5 - 1 mm	See field gauge card
Medium Sand	No. 60 - 35	0.25 - 0.5 mm	See field gauge card
Fine Sand	No. 120 - 60	0.125 - 0.25 mm	See field gauge card
Very Fine Sand	No. 230 - 120	0.0625 - 0.125 mm	See field gauge card
Silt and Clay. See SOP for description of fines	Not Applicable	<0.0625 mm	Analyze by pipette or hydrometer

PARTICLE PERCENT COMPOSITION ESTIMATION



GRAPH FOR DETERMINING SIZE OF PARTICLES



FOR COARSE-GRAINED SOILS

Description	Criteria
	Descriptor - Angularity
Angular	Particles have sharp edges and relatively planar sides withunpolished surfaces.
Subangular	Particles are similar to angular but have rounded edges.
Subround	Particles have nearly planar sides but have well-roundedcorners and edges.
Round	Particles have smoothly curved sides and no edges.
Minor Components with Descriptors	
	Sorting Cu= d60/d10
Well Sorted	Near uniform grain-size distribution Cu= 1 to 3.
Poorly Sorted	Wide range of grain size Cu= 4 to 6.
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Density
Very loose	N-value 1 - 4
Loose	N-value 5 - 10
Medium Dense	N-value 11 - 30
Dense	N-value 31 - 50
Very dense	N-value >50
Color using Munsell	
Geologic Origin (if known)	
Other	
	Cementation
Weak Cementation	Crumbles or breaks with handling or little finger pressure.
Moderate Cementation	Crumbles or breaks with considerable finger pressure.
Strong Cementation	Will not crumble with finger pressure.
	Reaction with Dilute HCl Solution (10%)
No Reaction	No visible reaction.
Weak Reaction	Some reaction, with bubbles forming slowly.
Strong Reaction	Violent reaction, with bubbles forming immediately.

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10 -15 feet SAND, medium to very coarse, little granules to medium pebbles, subround to subangular, trace silt; poorly sorted, wet, grayish brown (10YR 5/2).

SOIL DESCRIPTION FIELD GUIDE (APRIL, 2022; REV. 3.0)

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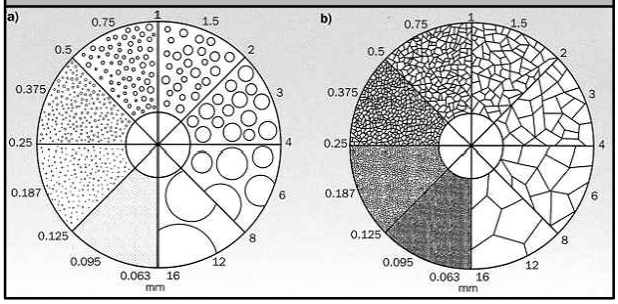
VARIATIONS IN SOIL STRATIGRAPHY

Term	Thickness of Configuration
Parting	0 - to 1/16-inch thickness.
Seam	1/16 - to 1/2-inch thickness.
Layer	1/2 - to 12-inch thickness.
Stratum	> 12-inch thickness.
Pocket	Small erratic deposit, usually less than 1 foot in size.
Varved Clay	Alternating seams or layers of sand, silt, and clay (laminated).
Occasional	≤ 1 foot thick.
Frequent	> 1 foot thick.

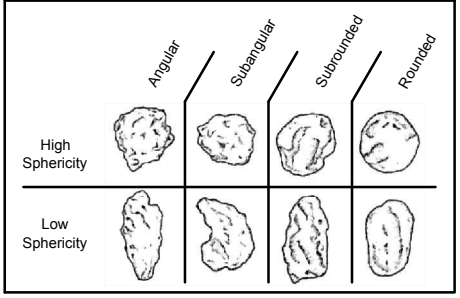
SOIL STRUCTURE DESCRIPTIONS

Term	Description
Homogeneous	Same color and appearance throughout.
Laminated	Alternating layers < 1/4 inch thick.
Stratified	Alternating layers ≥ 1/4 inch thick.
Lensed	Inclusions of small pockets of different materials, such as lenses of sand scattered through a mass of clay; note thickness.
Blocky	Cohesive soil can be broken down into small angular lumps, which resist further breakdown.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear to be polished or glossy, sometimes striated.

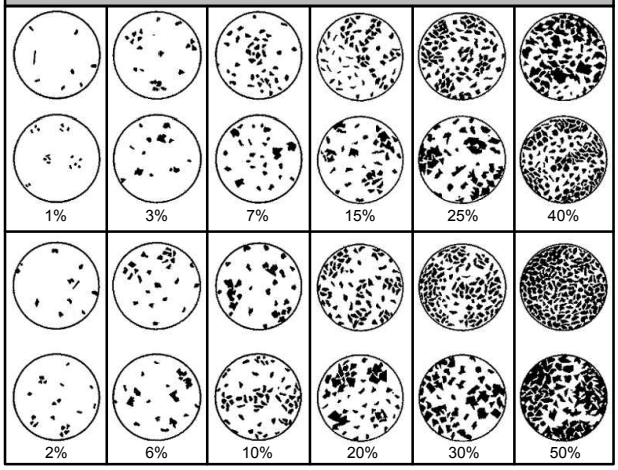
GRAPH FOR DETERMINING SIZE OF PARTICLES



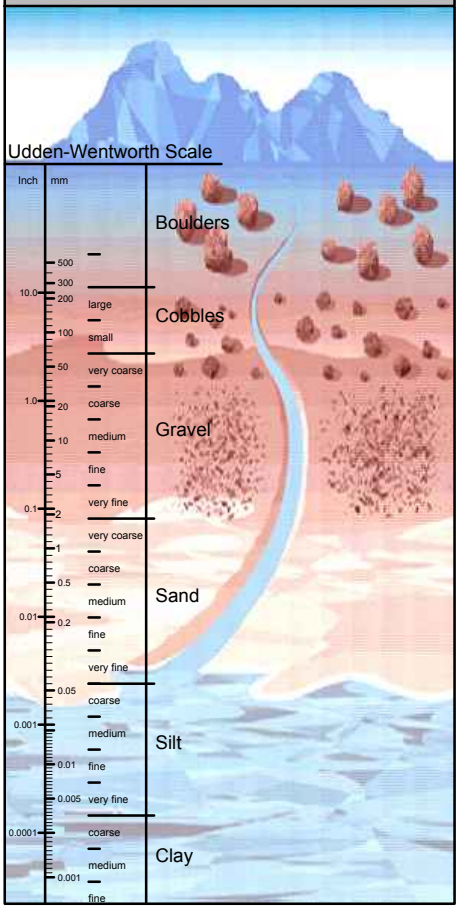
ANGULARITY CHART



PARTICLE PERCENT COMPOSITION ESTIMATION



SORTING



SETTLING TABLE (SILT/CLAY)

Diameter of Particle (mm)	<0.625	<0.031	<0.016	<0.008	<0.004	<0.002	<0.0005
Depth of Withdrawal (cm)	10	10	10	10	5	5	3
Time of Withdrawal	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec
Temperature (Celsius)							
20	00:00:29	00:01:55	00:07:40	00:30:40	00:61:19	04:05:00	37:21:00
21	00:00:28	00:01:52	00:07:29	00:29:58	00:59:50	04:00:00	
22	00:00:27	00:01:50	00:07:18	00:29:13	00:58:22	03:54:00	
23	00:00:27	00:01:47	00:07:08	00:28:34	00:57:05	03:48:00	
24	00:00:26	00:01:45	00:06:58	00:27:52	00:55:41	03:43:00	33:56:00
25	00:00:25	00:01:42	00:06:48	00:27:14	00:54:25	03:38:00	
26	00:00:25	00:01:40	00:06:39	00:26:38	00:53:12	03:33:00	
27	00:00:24	00:01:38	00:06:31	00:26:02	00:52:02	03:28:00	
28	00:00:24	00:01:35	00:06:22	00:25:28	00:50:52	03:24:00	31:00:00
29	00:00:23	00:01:33	00:06:13	00:24:53	00:49:42	03:10:00	
30	00:00:23	00:01:31	00:06:06	00:24:22	00:48:42	03:05:00	

Attachment B

Particle Size System Comparison

The purpose of this attachment is to illustrate how the Udden-Wentworth particle sizes and descriptive terms compares to other particle size systems.

When in the field, it is a customary practice to compare current soil descriptions to historical soil boring logs for reference purposes. When reviewing boring logs prepared by others, field staff should first note the particle size system used and recognize these particle size systems may differ. This will avoid confusion when cross referencing between historical and new boring logs and when reviewing existing geologic cross-sections.

For example, a well-sorted sand with grain sizes ranging from 1 to 2 mm should be classified as a very coarse sand by the Udden-Wentworth system. As shown in this attachment, the same particle size would be classified as a medium sand by the United Soil Classification System. The later system has fewer particle size grades and in general, is less descriptive than the Udden-Wentworth system.

PARTICLE SIZE SYSTEM COMPARISON

Grain size distribution in millimeters (mm)

Udden-Wentworth — Remediation Geologists and Engineers

		V. Fine	Fine	Medium	Coarse	V. Coarse	Granule	Pebbles				Cobbles		
								Small	Medium	Large	V. Large	Small	Large	
CLAY	SILT	SAND					GRAVEL							
0.039	0.065	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	
	1/16	1/8	1/4	1/2										

United Soil Classification System — Geotechnical Engineers

		Fine	Medium	Coarse	Fine	Coarse	
CLAY	SILT	SAND			GRAVEL		COBBLE
	0.074	0.42		2	4.75	19	75	300

U.S. Dept. of Agriculture — Soil Scientists

		V. Fine	Fine	Medium	Coarse	V. Coarse	
CLAY	SILT	SAND					GRAVEL
0.002	0.05	0.10	0.25	0.5	1	2	75

Remediation Hydraulics 2008, page 195): The Udden-Wentworth scale is preferred "...because the geometric progression of grain-size diameter also reflects relationships that are important when considering the erosion and deposition of sediments during the depositional process. The correlation between increasing grain size and degree of sorting and permeability is the most important, as permeability structure is responsible for the mobile and immobile porosity within aquifer systems. "

Attachment C

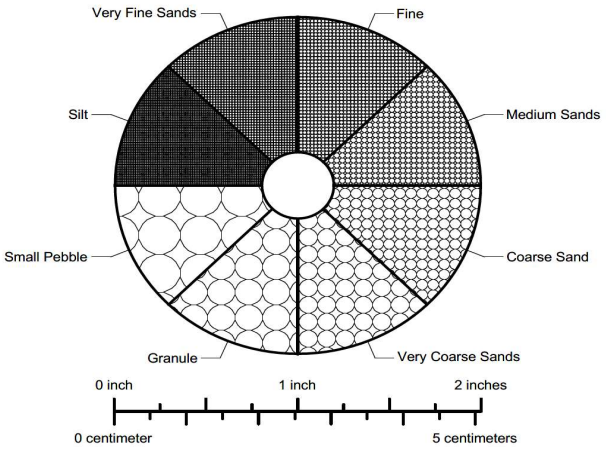
Description of Soil Logging Terms

The purpose of this attachment is to concisely define the soil logging terms used when filling out boring logs. During report preparation, project staff could use this sheet as an index placed in front of the completed boring logs. Also, it can serve as a supplemental reference sheet during field activities.

Description of Logging Terms

Note: Soil descriptions based on Arcadis Technical Guidance and Instructions (TGI) procedures. Key terms defined below.

GRAPH FOR DETERMINING SIZE OF PARTICLES



Udden Wentworth Soil Sizes

Boulder	> 256 mm
Large Cobble	128 to 256 mm
Small Cobble	64 to 128 mm
Very Large Pebble	32 to 64 mm
Large Pebble	16 to 32 mm
Medium Pebble	8 to 16 mm
Small Pebble	4 to 8 mm
Granule	2 to 4 mm
Very Coarse Sand	1 to 2 mm
Coarse Sand	0.5 to 1 mm
Medium Sand	0.25 to 0.5 mm
Fine Sand	0.125 to 0.25 mm
Very Fine Sand	0.062 to 0.12 mm
Silt/Clay	<0.065 mm

Primary Texture *(e.g. CLAY, SILT, SAND, GRANULE, PEAT, MUCK, FILL, etc.)*
List particle size with the highest percentage per sample interval (e.g. SAND)
Always CAPITALIZE the primary texture
Follow primary texture with a comma followed by grain-size descriptors, etc.

Minor Texture

And	(36 to 50%)
Some	(21 to 35%)
Little	(10 to 20%)
Trace	(>10%)

Angularity

Angular	Sharp edges
Sub-Angular	Rounded edges
Sub-Rounded	Well-rounded
Rounded	Smooth curved edges

Sand Density (Blow Counts/ft)

Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	<50

Silt/Clay Consistency (Blow Counts/ft)

Very Soft	0-2,	thumb easily penetrates several inches
Soft	3-4,	thumb easily penetrates one inch
Medium Stiff	5-8,	thumb indents 0.5 in. with much effort
Stiff	9-15,	thumb indents 0.25 in. with great effort
Very Stiff	16-30,	thumbnail is readily intended

Sorting

Well Sorted	1 to 3 Particle Sizes
Poorly Sorted	4+ Particle Sizes

Moisture Content

Dry	Dry to touch
Moist	No visible water
Wet	Visible free water

Plasticity (for silts and clays)

Non-Plastic	3 mm thread can not be rolled
Low Plasticity	3 mm thread can barely be rolled
Medium Plasticity	3 mm thread can easily and quickly rolled, but not rerolled
High Plasticity	3 mm thread can be rolled slowly, but can be rerolled

Dilatancy (for silts and silt-sand mixtures)

None	No visible change in the specimen
Slow	Water appears slowly during shaking / disappears slowly or not at all upon squeezing
Rapid	Water appears quickly during shaking / disappears quickly upon squeezing

Example Description

10 -15 feet SAND, medium to very coarse, little granules to medium pebbles, subround to subangular, trace silt; poorly sorted, wet, grayish brown (10YR5/2).

Attachment D

Blank Boring Log

The purpose of this attachment is to present a blank field form for use during soil logging. A digital version (Microsoft Excel) of this field form is available from the authors (upon request). If project specific modifications to this boring log template are warranted, please contact the Site Investigation Community of Practice leader for further assistance.

BORING LOG

ARCADIS

Boring ID:		**Project Name:**		**Page:**	/
Permit ID:		**Date Started:**		**Ground Elevation:**	
Site Address:		**Date Completed:**		**Vertical Datum:**	
City, State:		**Total Depth:**		**Northing:**	
Drilling Co:		**Depth to Water:**		**Easting:**	
Driller:		**Hole Diameter:**		**Horizontal Datum:**	
Drilling Method:		**Core Device:**		**Prepared by:**	
Boring Status:		**Drilling Fluid:**		**Reviewed by:**	

Drilling Information				Graphical Log for Primary Texture									Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel			
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	Vapor Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth Interval (ft), PRIMARY TEXTURE, Principal and Minor Components with Descriptors (% modifiers and grain size fraction, angularity for coarse sand and larger); Consistency/Density, Plasticity (clay or clay mix) or Dilatancy (silt/silt-sand), Sorting, Moisture Content, Color. NOTES: *Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)*	Driller's Observations, Geologic Formation, Field Screening Results, Sample Interval etc.

BORING LOG

Boring ID: _____ **Project Name:** _____ **Page:** / _____

Drilling Information				Graphical Log for Primary Texture										Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel				
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	Vapor Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth Interval (ft), PRIMARY TEXTURE, Principal and Minor Components with Descriptors (% modifiers and grain size fraction, angularity for coarse sand and larger); Consistency/Density, Plasticity (clay or clay mix) or Dilatancy (silt/silt-sand), Sorting, Moisture Content, Color. NOTES: *Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)*	Driller's Observations, Geologic Formation, Field Screening Results, Sample Interval etc.

Attachment E

Completed Boring Log

The purpose of this attachment is to provide an example of a completed boring log for reference purposes to field staff. The example provided is for a soil boring completed outside the waste mass of a closed municipal landfill near Baltimore, Maryland. The objective of the drilling program was to determine the depth to groundwater to determine the appropriate depth interval to install a soil gas monitoring well and groundwater monitoring well across the first water-bearing zone. The site geology consists of unconsolidated sediments of the Mid-Atlantic Coastal Plain, specifically the Upper Patapsco formation. These sediments were deposited in a moderate gradient fluvial environment during the Cretaceous period. The landfill was constructed into a regional clay confining unit.

BORING LOG

ARCADIS

Boring ID:	MW-08	**Project Name:**	Acme Landfill	**Page:**	1 / 1
Permit ID:	MD-PG-100	**Date Started:**	7/18/2018	**Ground Elevation:**	50.5 ft
Site Address:	100 Landfill Road	**Date Completed:**	7/18/2018	**Vertical Datum:**	NAVD 88, feet
City, State:	Baltimore, Maryland	**Total Depth:**	35 ft below ground	**Northing:**	123456.79
Drilling Co:	Earth Matters	**Depth to Water:**	19 ft below ground	**Easting:**	123456.79
Driller:	Rod E. Piper	**Hole Diameter:**	2-inch	**Horizontal Datum:**	NAD 83 feet, MD State
Drilling Method:	Direct-push/hollow-stem	**Core Device:**	5-foot macrocore sampler	**Prepared by:**	Sandy Pebbles
Boring Status:	completed as well	**Drilling Fluid:**	none	**Reviewed by:**	Clay Brown

Drilling Information				Graphical Log for Primary Texture											Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel					
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	VOC Vapor Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth Interval (ft), PRIMARY TEXTURE, Principal and Minor Components with Descriptors (% modifiers and grain size fraction, angularity for coarse sand and larger); Consistency/Density, Plasticity (clay or clay mix) or Dilatancy (silt/silt-sand), Sorting, Moisture Content, Color. NOTES: *Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)*	Driller's Observations, Geologic Formation, Field Screening Results, Sample Interval etc.
0 to 1			< 1												0-0.5 ft, topsoil with organics	Grass covered area
1 to 2			< 1				X								0.5-5 ft, SAND, fine, trace silt, trace pebble, round; poorly sorted, moist, yellowish brown (7.5 YR 5/8). NOTE: some cementation, does not react with HCl	continuous macro-core logging
2 to 3	0-5	43.2/60	< 1				X									
3 to 4			< 1				X									cemented sand @3.6-4 ft
4 to 5			< 1				X									
5 to 6			< 1				X	X	X						5-10 ft, SAND, fine to coarse, round to subround; well sorted, moist, light to strong brown (7.5 YR 6/4 to 7.5 YR 5/6).	
6 to 7			< 1				X	X	X							
7 to 8	5-10	40.8/60	< 1				X	X	X							
8 to 9			< 1				X	X	X							
9 to 10			< 1				X	X	X							
10 to 11			< 1				X	X	X						10-12.5 ft, same as above with trace silt	
11 to 12			< 1				X	X	X							
12 to 13	10-15	36/60	< 1				X	X	X							
13 to 14			< 1				X	X	X						12.5 to 15 ft, same as above, color change to pink (7.5 YR 7/3) and reddish yellow (7.5YR 6/8)	
14 to 15			< 1				X	X	X							
15 to 16			< 1						X	X					15-18.9 ft, SAND, coarse to very coarse, round to subround; well sorted, moist, strong brown (7.5YR 5/6) to reddish yellow (7.5YR 6/6)	
16 to 17			< 1						X	X						
17 to 18	15-20	55.2/60	< 1						X	X						
18 to 19			< 1		X	X	X								18.9-22.7 ft, SAND, very fine to fine, and SILT, coarse to very coarse, poorly sorted, wet, light gray (7.5YR 7/1)	water table encountered @ 18.9 ft
19 to 20			< 1		X	X	X									
20 to 21			< 1		X	X	X									
21 to 22			< 1		X	X	X									
21 to 23	20-25	36/60	< 1		X	X	X									
23 to 24			< 1	X	X										22.7-25 ft, CLAY and SILT; high plasticity, soft to stiff at 25 ft, dry to moist, light gray (2/5YR 7/1) w/ red mottling (2.5YR 4/6)	Middle Patapsco Confining Unit
24 to 25			< 1	X	X											
25 to 26			< 1	X	X										25-31.1 ft, CLAY and SILT; high plasticity, stiff; dry to moist, light gray (2/5YR 7/1) with red mottling (2.5YR 4/6)	
26 to 27			< 1	X	X											
27 to 28	25-30	30/60	< 1	X	X											
28 to 29			< 1	X	X											
29 to 30			< 1	X	X											
30 to 31			< 1	X	X											
31 to 32			< 1		X											
32 to 33	30-35 ft	60/60	< 1		X											
33 to 34			< 1		X										31.1-35 ft, SILT; high dilatancy; wet, gray (7.5YR 7/1)	End of direct-push boring @ 35 ft
34 to 35			< 1		X											

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TGI - Installation of Soil Vapor Probes

Rev: 4

Rev Date: April 30, 2025

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
1	1	12/12/2017	All	Initial TGI Development	Eric Epple Daniel Zuck Mitch Wacksman
2	2	1/3/2022	All	Revisions, Update to new format for QMS	Lindsey Deschenes Robert Uppencamp
3	3	1/25/2023	All	Annual review completed by Sarah Jonker Updated revision number and revision date; updated version control page as requested by Sarah Jonker on 1/25/2023.	Sarah Jonker
4	4	4/30/2025	All	Annual review; Several revisions throughout / complete rewrite	Sarah Jonker Brittany Fagin Eric Epple Lindsey Deschenes

Approval Signatures

Prepared by:		4/16/2025
	Brittany Fagin (Preparer)	Date
Reviewed by:		4/16/2025
	Sarah Jonker (Subject Matter Expert)	Date

1 Introduction

This Technical Guidance Instruction (TGI) provides the methods and procedures for installing soil vapor probes. Additional TGIs should be reviewed for procedures specific to soil vapor probe sampling. Methods for soil vapor sample collection are described in Arcadis documents *TGI: Sub-Slab Soil Vapor or Soil Vapor Sampling Using Whole Air Canisters Analyzed Via USEPA Method TO-15* and *TGI: Soil Vapor Sampling and Analysis using Sorbent Tubes for USEPA Method TO-17*. Check the QMS library for state specific TGIs according to your project location.

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

This TGI is recommended as a practical approach for the installation of soil vapor sampling probes where the intent is to collect soil vapor samples over one or more sampling events. Nested soil vapor probes (i.e., multiple sample depths inside a single boring) can also be installed using these methods. Drilling methods that can be used to advance borings for the installation of soil vapor probes includes hand auger, direct push, and hollow stem auger. Rotary sonic drilling and air-knife clearance is discouraged but may be necessary in certain circumstances. If rotary sonic drilling or air-knife clearance is necessary, discuss extended equilibration time

considerations. Soil vapor samples are often collected as part of vapor intrusion investigations associated with subsurface impacts. The project team is responsible for ensuring this procedure meets all applicable guidance or regulations in the jurisdiction where work is performed. Receiving approval/concurrence from the leading regulatory agency for the project is suggested prior to implementation.

Water level gauging, geotechnical sampling, soil sampling, and soil logging are often executed during soil vapor sampling or as part of a vapor intrusion investigation. These activities are outside the scope of this TGI.

4 Personnel Qualifications

Soil vapor probe installation activities will be performed by staff who have been trained on proper installation procedures. If geotechnical sampling, soil sampling, or soil logging are required as part of the scope of work it is critical that field personnel are appropriately trained for these additional tasks as described in the appropriate Technical Guidance Instructions (TGI)s for those activities.

5 Equipment List

The following materials will be available during soil vapor probe installation and soil logging activities, as required:

- Site Plan figure presenting proposed soil boring/well locations.
- Work Plan (or equivalent).
- Site-specific Health and Safety Plan (HASP) with task specific Job Safety Analysis (JSAs).
- Personal protective equipment (PPE), as required by the HASP and JSA
- Traffic cones, delineators, caution tape, and/or fencing, as appropriate.
- Probe tubing – new 1/4-inch outer diameter (OD) inert tubing (typically Teflon, Teflon-lined, or Nylon). Be aware that some regulatory agencies have requirements on the type of tubing to be used.
- Probe compression cap (to seal the tubing during equilibration).
- Probe screen and anchor point – ½-inch OD stainless steel screen, such as the Geoprobe Systems® implant, or similar. Several screen lengths are available for discrete intervals required in vapor intrusion investigations, a 6-inch screen is typically recommended. Make sure the diameter of the tubing connection (i.e., barbed, Swagelok®) on the top side of the screen matches the diameter of the sample tubing used for the installation.
- Hand tools including appropriate-sized open-end wrenches (typically 9/16-inch, 1/2-inch, and 3/4-inch), tubing cutters, etc.
- Drum labels as required for investigation derived waste (IDW) handling.
- Labels for sample soil vapor probe tubing. Stamped metal tags affixed with zip ties are recommended. Do not use tape.
- MultiRae® four or five-gas meter (or equivalent) for health and safety air monitoring during drilling.
- A photoionization detector (PID) capable of parts per million (ppm) readings.
- Landtec® GEM 5000 landfill gas meter (or equivalent).
- Decontamination equipment including bucket, distilled or deionized water, cleansers (Alconox®, TSP, or similar) appropriate for removing expected chemicals of concern and paper towels.

- Engineer's tape/measuring wheel.
- Weighted tape.
- Digital camera or phone with camera (confirm client approval).
- Field notebook and/or FieldNow® digital app (preferred).
- Appropriate field forms.

If soil sampling or soil logging is required by the project additional materials may be required per the appropriate TGIs for these tasks.

Prior to mobilizing to the site, Arcadis personnel will contact the drilling subcontractor to confirm that appropriate equipment will be provided. Specifications of the installation equipment are expected to vary by project, and so communication with the driller is necessary to ensure that the materials provided will meet the project objectives. It is strongly recommended that Arcadis personnel provide sample tubing, probes, and fittings and not the drillers.

Equipment/materials typically provided by the driller could include:

- Disposable plastic liners (when drilling with direct-push equipment);
- Drums for investigation derived waste;
- Drilling decontamination materials;
- Boring equipment: hand auger and/or drill rig equipped with direct push or rotary auger capability;
- Clean filter silica sand (#2 or larger);
- Granular bentonite or bentonite powder (bentonite chips are discouraged);
- Hydraulic or non-shrink cement grout;
- Tremie pipe with funnel or manual grout pump (1-inch OD PVC Pipe);
- Applicable materials to install watertight protective casing (flush traffic rated well box or stand-pipe) to be discussed with drilling contractor prior to mobilization.

6 Cautions

Pre-installation considerations:

- Underground utilities in the vicinity of the drilling areas must be delineated by the drilling contractor or an independent underground utility locator service prior to soil vapor probe installation. See Arcadis Utility Clearance HS Standard and HASP for detail. An Arcadis Utility Clearance Checklist must be completed and discussed with the project manager and team. There should be a clear understanding of subsurface conditions at the site, with a minimum of 3 quality lines of evidence used.
- A field mobilization memo, work plan or scope of work should be reviewed and discussed with team members (office, field, and subcontractors) prior to implementation to ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all.

- Soil vapor probe installation is not recommended within 48 hours after a significant rain event (defined as >1 inch of rainfall), as saturated soils could present a false saturated soil interval which could lead to inaccurate screen settings.
- Field personnel should not handle substances that could contain VOCs and lead to cross-contamination. These include marking paint, hand sanitizers, fuels and solvents or oils prior to handling soil vapor construction materials. Clean nitrile gloves should be used when handling any probe components (this includes the drilling contractor). Field personnel should **not use sharpie markers** during installation or note taking.
- Gravel or dense clay may make direct push drilling methods impracticable. Site geology should be discussed with the project technical lead and drilling contractor prior to field work.
- Ensure all soil vapor sampling probes are decontaminated and compatible with sample tubing prior to field mobilization. A two-stage decontamination process is preferred consisting of a soap wash that consists of distilled water detergent (Alconox®, TSP, or similar), then a final rinse with distilled water. The equipment should be allowed to air dry before use. When 1,4-dioxane is a site-specific constituent of concern, TSP (trisodium phosphate) should be used. Refer to the Arcadis *TGI – Decontamination of Components for Vapor Intrusion Sampling* for further guidance.

Installation Considerations:

- Depth to Groundwater – soil vapor samples must be collected in the vadose zone (and above the capillary fringe). The bottom of the soil vapor probe must be above the capillary fringe, typically 2-feet above groundwater depth, if feasible. Depths of perched water zones should also be considered. Review historical groundwater data for seasonal high groundwater depths to support installation depth and considering gauging nearby monitoring wells if accessible.
- Use of an air knife or vacuum truck is not recommended. Some jurisdictions explicitly prohibit the use of an air knife for soil vapor probe installation. However, if manual (hand auger) soil boring clearance is impractical based on soil lithology, use of an air knife or vacuum truck should be discussed as an alternative with the project team and used sparingly. Significant equilibration time will be required prior to sampling when an air knife or vacuum truck is used.
- Vapor probes can be finished at the ground surface with a flush mount traffic rated road box or vault (preferred) or with a standpipe protective casing, similar to groundwater monitoring wells.
- Soil permeability - It may not be feasible to collect soil vapor from finer-grained or tight soils with little pore volume, such as clays or dense dry silts; if there are known clay layers present in the subsurface, these intervals should be avoided when setting vapor probes. During the installation process, it is advisable to collect a soil core from the proposed sampling interval prior to installing the soil vapor probe to identify the exact depth of the capillary fringe and/or determine where the most permeable soil layers are located. For sampling in tighter soils, it is recommended that permanent soil vapor implants be installed with a wider borehole diameter.

7 Health and Safety Considerations

Field activities associated with soil vapor probe installation will be performed in accordance with a site-specific HASP and applicable JSA, a copy of which will be present on site during such activities.

8 Procedure

The depth of each soil vapor probe should be discussed and determined by the project team prior to beginning installation procedures. Under normal circumstances soil vapor probe should not be shallower than 5-feet below ground surface (bgs). Soil vapor probe placement is project specific and based on site objectives, however as a general consideration soil vapor probes must be installed in dry conditions approximately 2-feet above the water table or perched soil moisture.

All drilling equipment must be decontaminated prior to use and between each boring/installation. Handle and store decontaminated soil vapor probes in a manner that prevents contamination, such as in a Ziploc® bag prior to use. Record the outer diameter of the drilling equipment for an accurate borehole diameter.

Inspect vapor probe parts and drilling equipment for wear and faulty parts. Have the driller replace probe tips, o-rings, adapters, and probe rods as appropriate.

The procedures below allow the installation of a soil vapor probe. If multiple depths are to be installed, steps 3-6 are repeated, starting with the deepest sample interval.

1. Hand clear boring location as specified in HASP. If an air knife is used, discontinue use 1-foot above the top of the sample interval and finish boring using a hand auger or drill rig tooling.
2. Record in the field log the soil type and any PID readings that were collected from soil cuttings removed during installation. If saturated soils are encountered, plug the interval(s) with granulated bentonite up through the last dry interval and hydrate to properly seal.
3. After reaching the desired depth, install sample screen and tubing. Place the screen and tubing into the open borehole or have the driller place inside the direct push drill pipe along with the push tip.
4. Once in place, install the required amount of clean silica sand (as specified in Step 3 based on soil type). Add clean silica sand to create an appropriate sand pack. Typically, there are 3 inches of clean silica sand both above and below a 6-inch sample screen, along with the clean silica sand surrounding the screen, creating a 12-inches total screen/sand interval.
5. Withdraw the drill pipe 6 inches and place 6 inches of dry granulated bentonite on top of the clean sand layer.

   Add hydrated granular bentonite or bentonite slurry to 12-inches below the ground surface, or bottom of next sample interval (for nested installations). Install appropriate surface finish (i.e., bolting watertight road box, stick-up). If nested ports are not installed and the depth is greater than 10-feet below grade, a bentonite slurry grout may be placed above the granulated bentonite to 1-foot below grade. For temporary probes, to be destroyed shortly after sampling, only use hydrated bentonite up to 12-inches below ground surface.

   a. For permanent probe installation at California sites (subject to DTSC VI Guidance), add 6-inches of hydrated granular bentonite and let it set for a minimum of 30 minutes. After the bentonite is set, pour Portland Neat Cement Type I/II up to 12-inches below ground surface as the annular seal.

6. The remaining annulus within the road box may be filled with non-shrink grout cement or hydrated granular bentonite to approximately 0.5-foot below ground surface, or enough to seal the tubing to the protective casing. Place 2 to 3 inches of sand on top of the cement to ensure that the tubing and fittings do not make contact with the cement during curing or hydrated granular bentonite.
7. Cut sample tubing long enough to allow enough length to sample in the future. For flush mounted casings, 2 to 3 feet of tubing is recommended. For stand-pipe casing, make sure there is at least 6 to 7-feet of tubing extending above grade. Terminate sample tubing using an airtight plug or valve with compression fittings (stainless steel is recommended).
8. Clearly label sample probe and protective casing with ID and depth. Stamped metal tags affixed with stainless zip ties are recommended.
9. Allow at least 24-hours for soil vapor probe equilibration and cement curing prior to leak testing and sampling. See applicable TGIs and applicable state guidance for specifically required equilibration times typically determined based on drilling methods used.

An example of a finished nested soil vapor probe is presented in the schematic below.

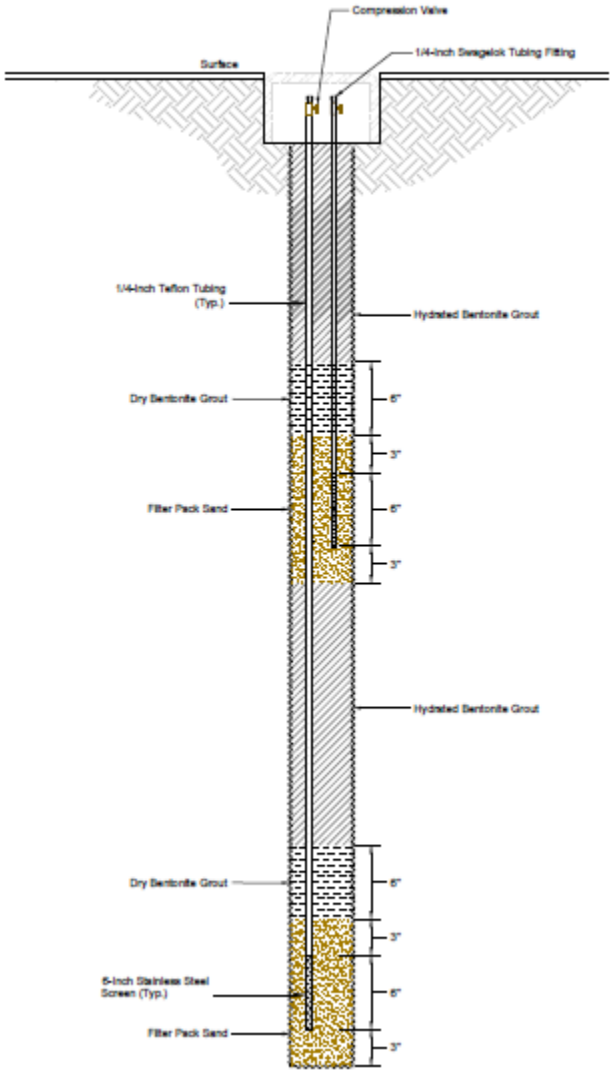

Figure 1. Nested soil vapor probe construction schematic.

9 Waste Management

Investigation-derived wastes (IDW), including soil cuttings, decontamination liquids, and disposable materials (material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan (or equivalent), field sampling plan (FSP), and/or IDW management guidance document.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

Drilling activities should be documented on appropriate field/log forms (see Attachment A) as well as in a proper field notebook. Additionally, all documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of installation activities, soil descriptions, construction specifications (backfill material and borehole diameter, tubing length, screen details, seal type), and quantities of materials used. In addition, the locations of newly installed soil vapor probes will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features. The well location will be surveyed using the method specified in the site Work Plan (or equivalent).

11 Quality Assurance

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate TGI. New tubing should be used for every installation. Soil vapor probe materials will also be cleaned prior to well installation. Refer to the Arcadis *TGI – Decontamination of Components for Vapor Intrusion Sampling* for further guidance.

12 References

California Environmental Protection Agency (CalEPA) – Department of Toxic Substances Control (DTSC). 2015. Advisory – Active Soil Gas Investigations (https://dtsc.ca.gov/wp-content/uploads/sites/31/2021/11/VI_ActiveSoilGasAdvisory_FINAL_a.pdf). July.

Interstate Technology Regulatory Council (ITRC). 2007. Technical and Regulatory Guidance. Vapor Intrusion Pathway: A Practical Guideline (https://itrcweb.org/wp-content/uploads/2024/09/VI-1.pdf). January.

New Jersey Department of Environmental Protection (NJDEP) – Site Remediation and Waste Management Program. 2016. Vapor Intrusion Technical Guidance (https://dep.nj.gov/wp-content/uploads/srp/vig_main_4.0.pdf). August.

United States Environmental Protection Agency (USEPA) – Office of Solid Waste and Emergency Response (OSWER). 2015. Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from

Subsurface Vapor Sources to Indoor Air (https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf). June.

Attachment A

Single Soil Vapor Probe Construction Diagram

Nested Soil Vapor Probe Construction Diagram

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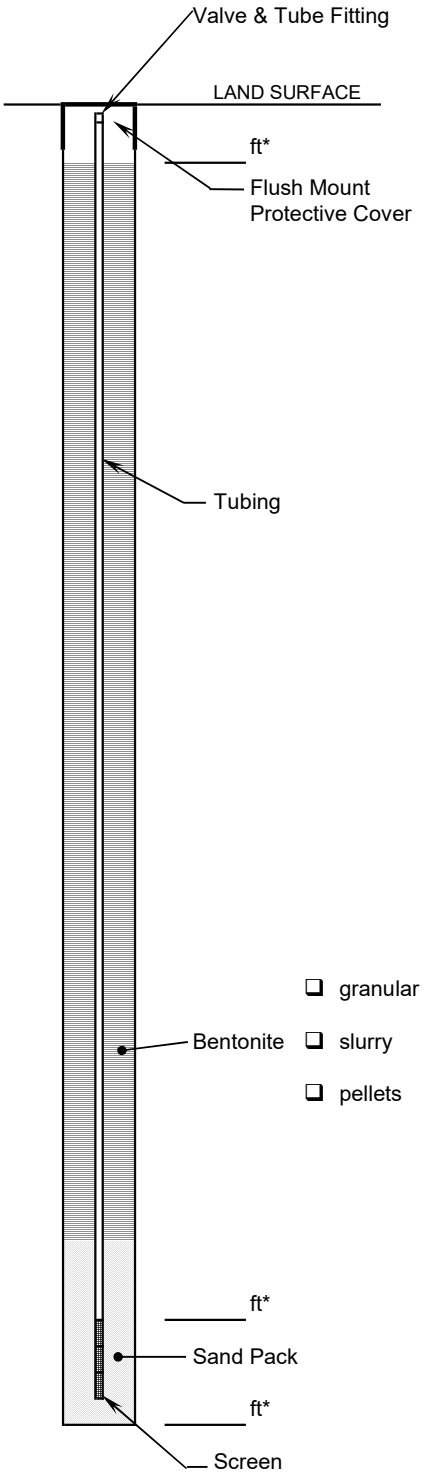
SINGLE SOIL VAPOR PROBE CONSTRUCTION DIAGRAM



* Depth Below Land Surface

Project: _____ Port: _____

City: _____

County: _____ State: _____

GPS Coordinates:

Latitude: _____

Longitude: _____

Land-Surface Elevation and Datum:

_____ feet

❑ Surveyed

❑ Estimated

Installation Date: _____

Weather Conditions at Installation: _____

_____

Drilling Contractor: _____

Driller: _____

Drilling Method: _____

Screen:

Construction: _____

Length: _____

Tubing:

Construction: _____

Diameter: _____

End Valve:

Type/Construction: _____

End Connection: _____

Remarks: _____

_____

_____

_____

_____

_____

_____

_____

Prepared by: _____

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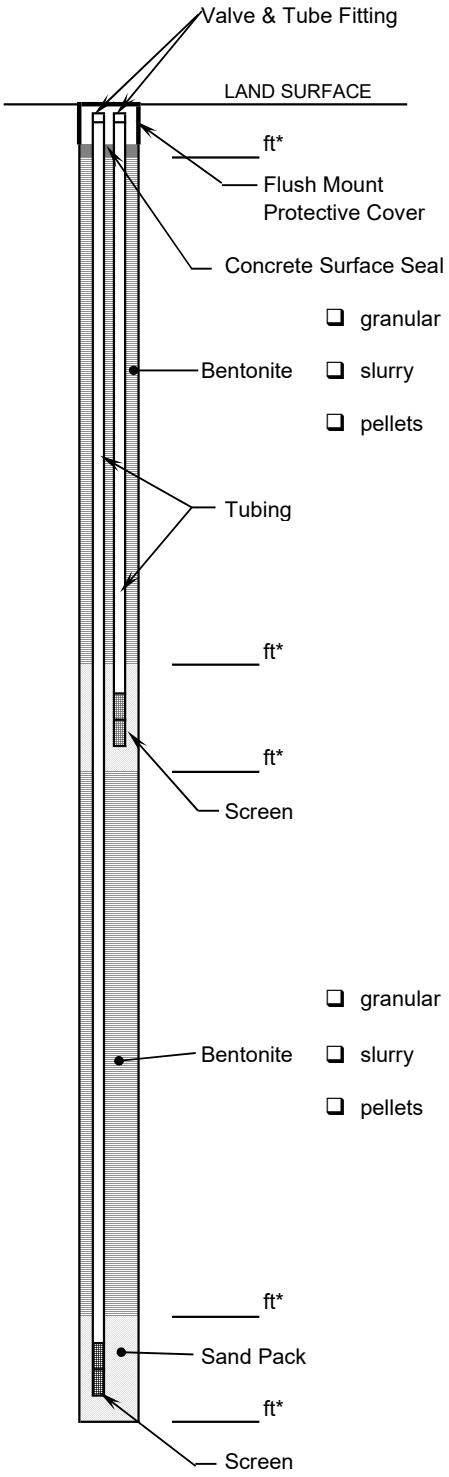
NESTED SOIL VAPOR PROBE CONSTRUCTION DIAGRAM



* Depth Below Land Surface

Project: _____ Port: _____

City: _____

County: _____ State: _____

GPS Coordinates:

Latitude: _____

Longitude: _____

Land-Surface Elevation and Datum:

_____ feet

❑ Surveyed

❑ Estimated

Installation Date: _____

Weather Conditions at Installation: _____

_____

Drilling Contractor: _____

Driller: _____

Drilling Method: _____

Screen:

Construction: _____

Length: _____

Tubing:

Construction: _____

Diameter: _____

End Valve:

Type/Construction: _____

End Connection: _____

Remarks: _____

_____

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TGI - Sub-Slab Vapor and Soil Vapor Sampling Using Whole Air Canisters

Rev: 3

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Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
1	1	9/18/2016	All	Updated Rev0	Mitch Wacksman
2	2	8/4/2023	All	Updated Rev1	Sarah Jonker Christina Weaver Robert Uppencamp
3	3	7/22/2025	All	Complete re-write to all sections.	Sarah Jonker Margaret Bartee

Approval Signatures

Prepared by:		7/22/2025
	Sarah Jonker	Date
Reviewed by:		7/22/2025
	Margaret Bartee	Date

1 Introduction

This Technical Guidance Instruction (TGI) provides the methods and procedures for collecting whole air samples via USEPA Method TO-15 from sub-slab vapor or exterior soil vapor using whole air stainless-steel canisters. It is advisable to consult with a vapor intrusion subject matter expert (SME) when planning and executing the procedures detailed in this TGI.

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

This Technical Guidance Instruction (TGI) has been updated to reflect United States Environmental Protection Agency (USEPA) criteria (USEPA 2015) and best practices.

This document describes the procedures for collecting exterior soil vapor or sub-slab soil vapor (herein referred to as "soil vapor") samples using whole air stainless-steel canisters for the analysis of volatile organic compounds (VOCs) by USEPA Method TO-15 (TO-15). This document assumes a sample port (either sub-slab port or exterior soil vapor probe) has already been installed. This document covers the above ground assembly and sampling methods.

Separate TGIs are available in the TGI library for the installation of sub-slab ports and exterior soil vapor probes. Sampling is typically able to commence a minimum of 2 hours after installation of a sub-slab port (VaporPin®) and a minimum of 24 hours after installation of a soil vapor probe. Confirm equilibration times with the project's regulatory jurisdiction.

Method TO-15 typically uses a 1-liter, 3-liter, or 6-liter stainless-steel canisters to collect a whole air sample. The whole air sample is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GS/MS) system to provide typical compound detection limits of 0.5 parts per billion volume (ppbv).

The following sections list the necessary equipment, materials, and detailed instructions for collecting soil vapor samples for VOC analysis.

4 Personnel Qualifications

Arcadis field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, Department of Transportation (DOT)/International Air Transport Association HazMat #1, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. Arcadis field sampling personnel will be well versed in the relevant technical guidance instructions (TGIs) and possess the required skills and experience necessary to successfully complete the desired field work. Arcadis personnel responsible for leading soil vapor sample collection activities must have previous soil vapor sampling experience.

5 Equipment List

The equipment required for soil vapor sample collection is presented below. All stainless-steel supplies must be cleaned/decontaminated prior to use.

5.1 Laboratory

- 1, 3, or 6-liter whole air stainless-steel canisters. Order either batch certified canisters or individually certified canisters as required by the project. Order at least one extra whole air stainless-steel canister per 20 samples to account for a potential loss of vacuum malfunction in shipping, if feasible. A 1-liter whole air stainless-steel canister is typical for soil vapor sampling and will achieve most reporting limit requirements. Confirm the applicable screening levels for the project will be met by the laboratory reporting limits.
- Flow controllers must be ordered for each whole air stainless-steel canister ordered. Flow controllers will come with in-line particulate filters and vacuum gauges. Flow controllers are pre-calibrated to specified sample duration (e.g., 5, 10, or 30 minutes) or flow rate (e.g., between 80-200 milliliters per minute [mL/min]). Confirm with the laboratory that the flow controller comes with a particulate filter and vacuum gauge.
- Order a stainless-steel duplicate tee as needed. Projects typically require 1 duplicate per 10 samples or 20 samples. Confirm the project QA/QC requirements.

5.2 Supplies

Soil vapor probes are typically completed with all sample assembly components permanently connected and contained within the manway vault. Purging materials and sampling media are required.

Supplies to build one sub-slab port assembly are listed below. Clean/decontaminate all stainless-steel supplies prior to use. Tubing and ferrules cannot be reused. Stainless-steel supplies should be Swagelok® or Parker A-Lok compatible compression fittings. Supplies can be purchased at companies such as Swagelok® www.swagelok.com, McMaster Carr www.mcmaster.com, or ESP Supply www.shop-esp.com.

Two sub-slab sample assembly types are detailed in Section 8. Materials to build each type of sample assembly are listed below.

Sub-Slab Port Assembly for Vapor Pin™ with Barb Fitting using the Sample Configuration with Purge Isolation

- 1: 1/4-inch stainless-steel valve with compression fittings.
- 6: 1/4-inch stainless-steel compression nuts.
- 6: 1/4-inch stainless-steel front and back compression ferrules.
- 1: 1/4-inch stainless steel union tee. Some labs have flow controllers with a purge port and valve built in. Confirm with the lab flow controller setup (request a diagram or photo). A Luer-Lok™ 3-way valve can be used at the tee fitting as well (single use).
- 36-inches: 1/4-inch outer diameter (OD) Teflon®, Teflon® lined, or Nylaflow tubing.
- 8-inches: 1/4-inch inner diameter (ID) silicone tubing.
- 50 or 60-mL syringe equipped with a three-way Luer-Lok™ valve. Alternately, a low-flow air pump may be used.
- 1-liter Tedlar® bag to collect purge air for the leak detection test, field parameter measurements, and venting outside a structure if working inside.

Sub-Slab Port Assembly for Vapor Pin™ with Barb Fitting using Separate Purge and Sample Configuration

- 1: 1/4-inch stainless-steel ball with compression fittings.
- 3: 1/4-inch stainless-steel compression nuts.
- 3: 1/4-inch stainless-steel front and back compression ferrules.
- 24-inches: 1/4-inch OD Teflon®, Teflon® lined, or Nylaflow tubing.
- 8-inches: 1/4-inch ID silicone tubing.
- 60-mL syringe equipped with a three-way Luer-Lok™ valve. Alternately, a low-flow air pump may be used.
- 1-liter Tedlar® bag to collect purge air for the leak detection test, field parameter measurements, and venting outside a structure if working inside.

5.3 Rental Equipment/Supplies

Appropriate equipment and materials for quality assurance testing are detailed in the respective quality assurance TGIs (i.e., helium leak testing, water dam testing, methane testing).

- Appropriate equipment and materials for quality assurance testing as laid out in the respective quality assurance TGIs (i.e., helium leak testing, water dam testing, methane testing).
- Low-flow air pump with time-elapse clock (GilAir or equivalent) capable of a flow rate between 100 ≤ to ≤ 200 mL/min for purging. This may require a low-flow module. Alternately, a 60-mL syringe with a three-way Luer-Lok™ valve may be used.

- Air pump calibration instrument such as a DryCal® Defender (or equivalent), as needed.
- Photoionization detector (PID) with calibration kit, as needed.
- Multi-gas monitor (LANDTEC® GEM™ 2000 PLUS/5000 or similar) capable of detecting percentage of carbon dioxide, methane, and oxygen with calibration kit, as needed.
- Helium detector (Dielectric MGD-2002 or similar).
- Ultra-high purity (UHP) helium tank with compatible regulator.
- Portable weather meter, as needed. Alternately, weather applications or weather websites can be used.

5.4 Personal Gear and Documents

- Appropriate-sized open-end wrench (typically 9/16-inch and 1/4-inch, #14 spanner for Vapor Pins®).
- 1/4-inch adjustable wrench.
- Channel locking plier with 1.5-inch or larger opening (helium tank manifold and 2-way valves).
- Non-VOC containing modelling clay to mitigate leaks such as Craft Smart Natural Clay (air-dry) or Pepy Plasticine (non-drying). Clay should have no color added and meet ASTM D-4236 standards for required clear labeling (This means they must include general VOCs or harmful ingredients in the label).
- Shroud (plastic bucket, garbage can, plastic bag, plastic drop cloth, laboratory provided helium leak detection kit, etc.).
- Sand filled socks, weighted chain, or equivalent to seal helium shroud when using a plastic bag or drop cloth.
- Chain-of-custody (COC) form(s) – lab supplied preferred.
- Nitrile gloves.
- Work gloves.
- Sample collection log, field notebook/tablet, or current Standard Vapor Intrusion Sampling FieldNow® application.

6 Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a soil vapor sample.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (e.g., Sharpie®), wear/apply fragrances including sunscreens, hand sanitizer, or alcohol-based cleaning products. Do not smoke cigarettes/cigars before and/or during the sampling event.
- Soil vapor sampling equipment and tools should be stored separately from adhesives with VOCs such as duct tape. Field staff should take note of any sanitation stations or recent use of chemicals within proximity of their sample locations.
- Tubing and piping materials commonly used for other types of sampling such as HDPE, LDPE, and PVC should not be used in soil vapor sampling. These materials can either absorb constituents of potential concern present in soil vapor or introduce VOCs via off gassing. Refer to Section 5 for the list of approved soil vapor sampling materials.

- Ensure the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory) by checking equipment inventory enclosed with equipment packaging and flow controller tags. Discuss discrepancies with project team prior to final mobilization for sampling. Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 2 to 10 inches of mercury [in Hg]) remains in the canister when sample collection is terminated.
- The helium detector will function correctly at high relative humidity levels of 50% or greater, but its accuracy and sensitivity may be reduced. In addition, high concentrations of methane can cause false readings. Use a multi-gas monitor to screen purged air during leak check if methane interference is anticipated. Review the TGI for *Administering Helium Tracer Gas Leak Test* for further details on helium leak testing.
- The integrity of the sample train and sample port will be tested in accordance with the project specific requirements. These procedures are contained in their own TGI documents and include helium leak testing, water dam testing, and methane testing.
- When conducting a shut-in test, pull the syringe slowly at a rate no faster than 1 to 2 mL/second (approximately 60 to 120 mL/min, the lower the better) to avoid damage to the flow controller, and stop pulling once you have achieved a vacuum. Most flow controllers are not constructed to withstand vacuum from the outlet side of the device, and therefore, rapid application of strong vacuum from a quick, full pull of a syringe can damage the internal components.
- It is important to record the canister vacuum, start and stop times, and sample identification on a proper field sampling form or current Standard Vapor Intrusion Sampling FieldNow® application. You should observe and record the time/ vacuum at the start, and then again one or two minutes after starting the sample collection. It is a good practice to lightly tap the vacuum gauge with your finger before reading it to make sure the needle is not stuck. If the canister is filling as expected, the sampling rate should match the rate of the flow controller set point. Consult your project manager, risk assessor, or air sampling expert by phone if the canister does not appear to be working properly due to insufficient or rapid pressure changes.
- Ensure that there is still measurable vacuum in the canister after sampling. The target residual vacuum is -5 inches Hg, however the acceptable range is between -2 in Hg and -10 in Hg. Sometimes the gauges sent from labs have off-set errors, or they stick.
- When sampling, carefully consider elevation. If your site is over 2,000 feet above sea level, or the difference in elevation between your site and your lab is more than 2,000 feet, then pressure effects will be significant. If you take samples at a higher elevation, they will contain less air for a given ending vacuum reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely, low elevation samples received by a laboratory at high elevation may appear to not have much vacuum left in them. Pressure at sea level is 1 atm which corresponds to 29.92 inches Hg. Enter the sample location (city/town) atmosphere (atm) into the Pressure Conversions Calculator to determine the difference in the corresponding pressure in inches of Hg: http://www.uigi.com/Atmos_pressure.html. For instance, the atmosphere in Denver, Colorado is 0.830 atm which corresponds to 24.83 in Hg. This indicates approximately 5 inches Hg difference from sea level.
- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Check the vacuum in each canister as soon as they arrive. The preference is a starting vacuum of -28 inches of Hg or more, but some canisters may be used in certain jurisdictions with lower starting vacuum. However, ff the initial vacuum registers less than -25 inches of Hg, then the canister is not appropriate for use and another canister should be used. The initial vacuum required varies by

jurisdiction; confirm with the project regulatory authority and project team prior to sampling. If an analog or digital gauge is available when conducting inventory, ensure the vacuum is similar to the laboratory recorded vacuum on the sample tag. Order replacements, if needed.

- Requesting extra canisters and flow controllers from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure, especially at remote sites.
- When taking field measurement readings of the soil vapor conditions, it is best practice to collect reading from a Tedlar® bag instead of directly from sample port. This is due to field instruments having a flow rate of greater than 200 ml/min, which can cause partitioning of contaminants during sampling. In addition, for health and safety reasons, when there are elevated concentrations of site contaminants it is best not to purge into the sampler's breathing zone.
- Considering laying out a new trash bag or tarp on the ground next to the sample port to prevent sampling equipment from touching potentially impacted ground (i.e., asphalt parking lot with car oil stains).
- Shallow exterior soil-gas sampling normally should not proceed immediately following a significant rain event. Consult applicable regulations and guidance for recommended wait times following precipitation events before sampling can proceed.
- This TGI is not a substitute for a Work Plan. Staff involved with a soil vapor sampling event must review the Work Plan prior to pre-field planning activities.

7 Health and Safety Considerations

All sampling personnel should review the appropriate health and safety plan (HASP) and job safety analysis (JSA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. Field sampling must be carefully performed to minimize the potential for injury and the spread of hazardous substances.

Soil vapor sampling is often done on the ground with workers on their knees. Low stools, knee pads, or a large pad can be used under the entire sample area (i.e., a large, folded box). This will protect the worker's knees. Ensure proper hand protection is worn while working with hand tools during sample train assembly. The metal-on-metal fittings often create small metal splinters, so always use gloves when handling thecanisters, fittings, valves, etc. Do not blow the splinters off towards other workers. Use outer nitrile gloves when handling all sample train components to prevent potential cross contamination.

Methane is encountered at some project sites, especially petroleum sites and in situ remediation sites. Package the canister and flow controller per DOT regulations for return shipment to the laboratory. These regulations can be found at the Transportation Safety Program's Team Site on the Source. The canister does not require preservation with ice or refrigeration during shipment. Refer to TGI – Soil Gas Methane Monitoring for Shipping Determination of Soil Gas Samples if sampling in an area with unknown or known methane conditions. A shipping determination form is required for shipment of any type of samples prior to field mobilization.

8 Procedure

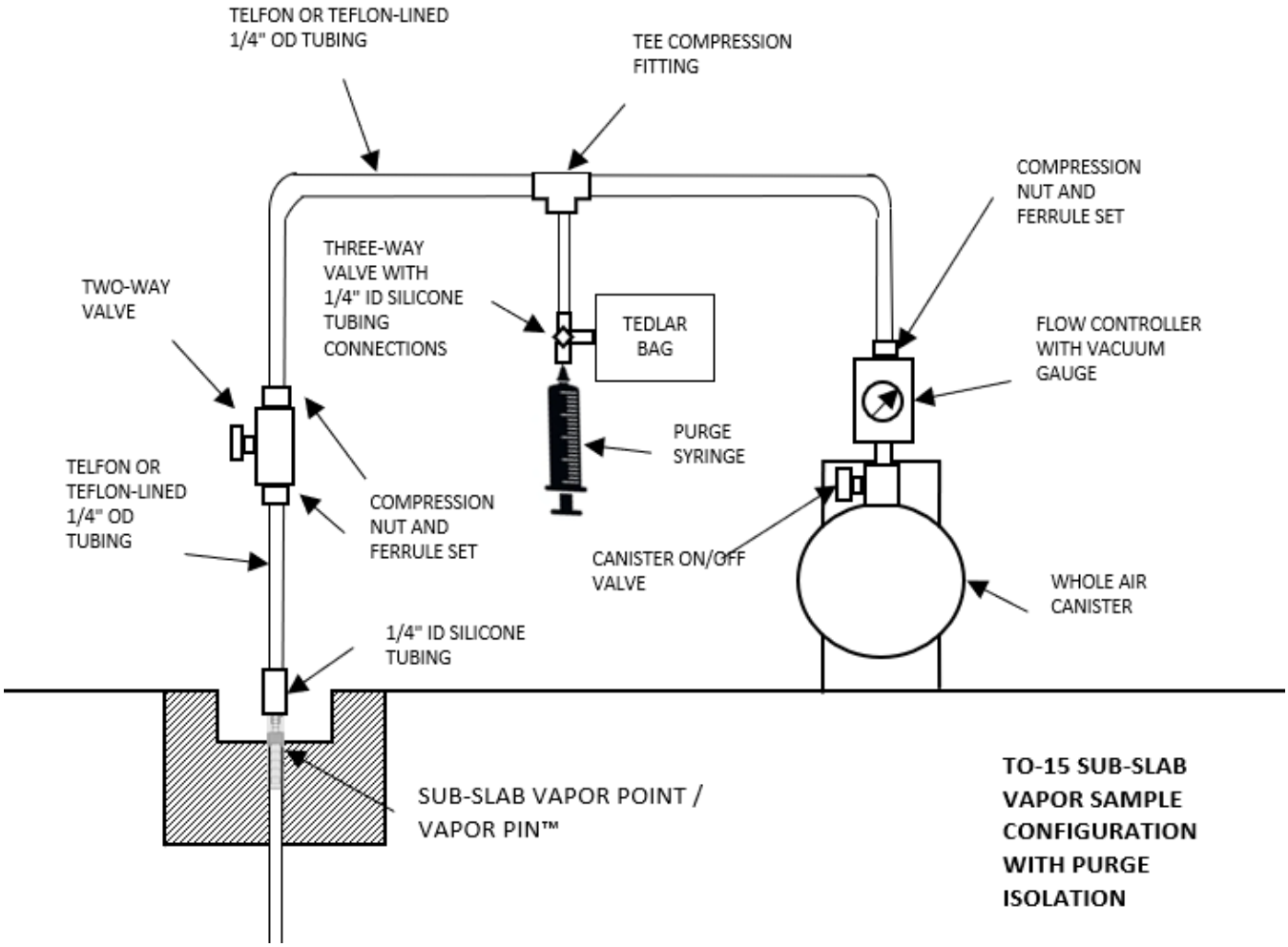
8.1 Sample Train Assembly

The following procedures should be used to collect a soil vapor sample using a whole air stainless-steel canister. These methods can be used for both soil vapor probe samples and interior sub-slab soil vapor samples collected from both permanent and temporary sample point installations. Two configurations of the sample train are acceptable in most jurisdictions; confirm with the project regulatory authority.

Sub-Slab Port Assembly for Vapor Pin™ with Barb Fitting using the Sample Configuration with Purge Isolation

1. Pre-assemble the sample train for each sub-slab port to be sampled (Vapor Pin® with barb fitting). Cut three ~10-inch pieces of 1/4- inch OD Teflon®, Teflon® lined, or Nylaflow tubing and 1 ~6-inch piece of the same tubing.
2. Connect one piece of the 10-inch tubing to the two opposite sides of the stainless-steel tee with compression nuts and ferrule sets. Install a compression nut and ferrule set to the other side of each tubing piece.
3. Remove the cap from the canister and connect the flow controller with in-line particulate filter and vacuum gauge. The flow controller attaches directly to the canister and the pre-set rate dictates the sample duration. The laboratory may have connected the canister and flow controller prior to shipping. Attach the canister and flow controller assembly to the tubing from one side of the stainless-steel tee.
4. Unless the flow controller manifold came with a purge port and valve, one will need to be added. Cut a short length (~6-inches) of 1/4- inch OD Teflon®, Teflon® lined, or Nylaflow tubing. Connect to the open end of the tee fitting using a compression nut and ferrule set. This tee adds a leg to the sample train that will be used to purge “dead” air from the sample train.
5. Connect the purge syringe with three-way valve and/or air pump to the free end tubing from the tee using a length short piece of 1/4-inch ID silicone tubing.
6. Attach a two-way compression valve to the remaining free end of the tee tubing. Cut another 6-inch piece of 1/4-inch OD Teflon tubing and connect to the other side of the two-way valve with a compression nut and ferrule set. The two-way valve will be immediately adjacent to the sample point in the train assembly. This valve is used to isolate the sample train from the sample point prior to sampling in order to test the sample train’s integrity. See Section 8.3 for purging details.
7. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two canisters using a stainless-steel compression duplicate sample tee-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample tee.
8. Attach the terminal end of the two-way compression valve to the sample port as appropriate. This may be done using the options below:
    a. Use a section of silicone tube to connect the Teflon sample tubing to the barbed fitting of a Vapor Pin® port.
    b. Use Swagelok® or equivalent compression fittings to connect Teflon tubing to the sample port. Teflon tape should never be used on Swagelok® or equivalent compression fittings.

A schematic of the first suggested sample train setup isolating the purge line is illustrated below:

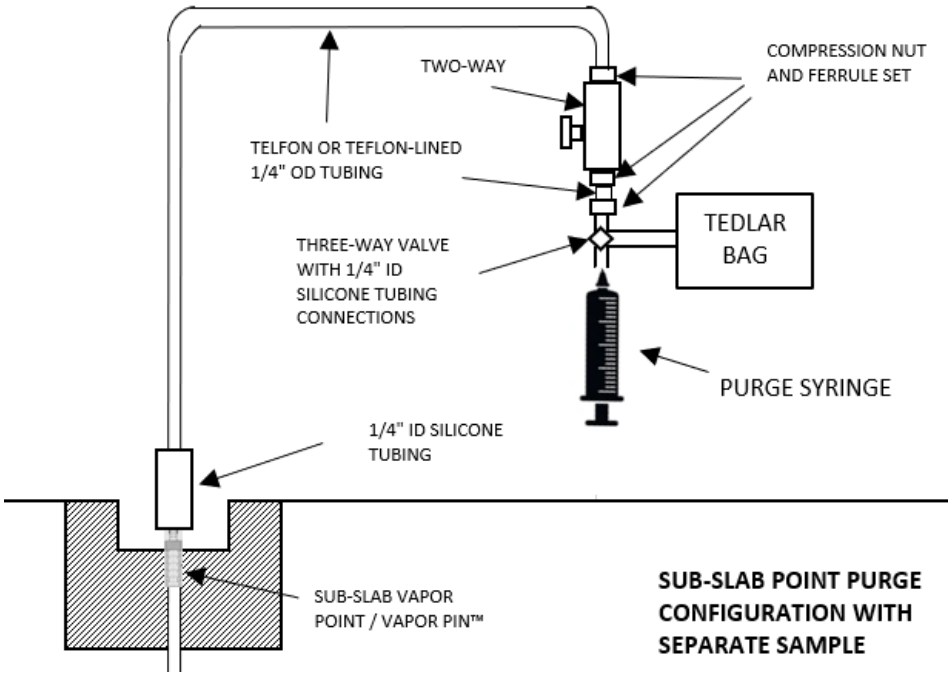


Sub-Slab Port Assembly for Vapor Pin™ with Barb Fitting using Separate Purge and Sample Configuration

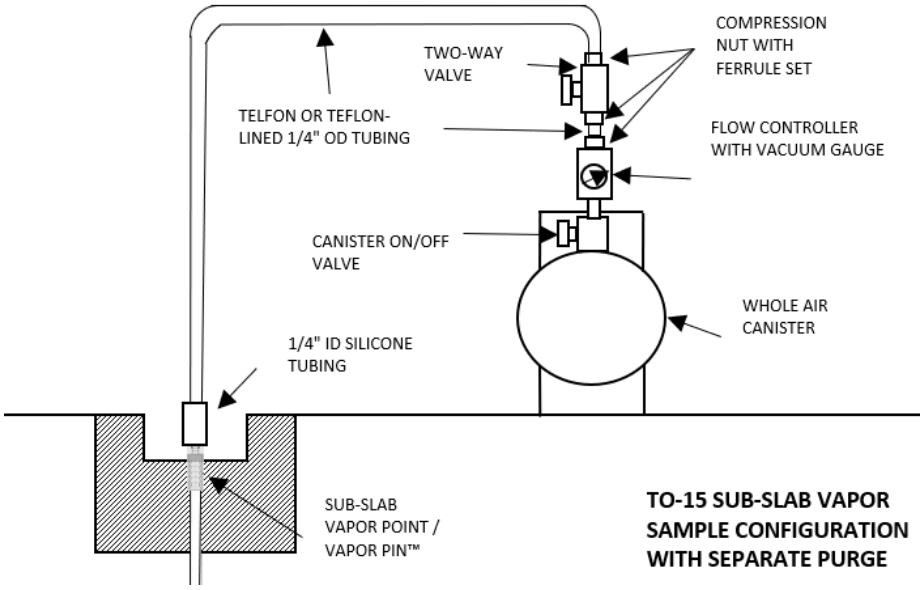
1. Pre-assemble the sample train for each sub-slab port to be sampled (Vapor Pin® with barb fitting). Cut an approximate 18-inch length and a 1-inch length of Teflon or Teflon-lined 1/4-inch OD tubing. Cut a 2-inch piece of 1/4-inch ID silicone tubing. Connect the silicone tubing to one end of the 18-inch length of tubing. Connect a stainless-steel two-way valve with compression fittings to the other side of the Teflon tubing. Connect the 1-inch piece of Teflon tubing to the other side of the two-way valve. Connect a compression nut and ferrule set to the other end of the 1-inch piece of Teflon tubing for the connection to the canister. This sample train is found within the well vault at permanent soil vapor probes.
2. Assemble the sample train by removing the cap from the canister and connecting the flow controller with in-line particulate filter and vacuum gauge. The flow controller attaches directly to the canister and the pre-set rate dictates the sample duration. The laboratory may have connected the canister and flow controller prior to shipping.

3. At sub-slab ports, connect the silicone end of the sample train to the barb fitting of the Vapor Pin®. For both sub-slab ports and soil vapor wells, connect a three-way valve to a syringe using the Lok-Lur tip. Connect one end of the sample train to the three-way valve with a 1-inch piece of silicone tubing and the last end to a Tedlar bag with a 1-inch piece of silicone tubing. A personal air pump capable of 200 milliliters per minute (mL/min) can be substituted for the syringe. See Section 8.3 for purging details.

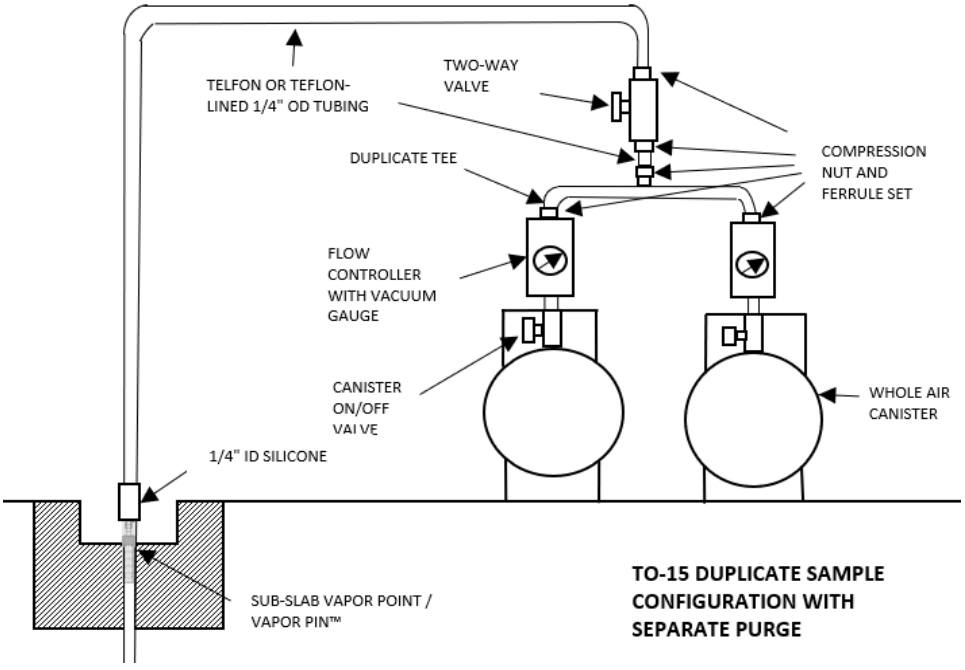
A schematic of the suggested second type of sample train setup is illustrated below:



4. Once purging is complete, close the two-way valve, then disconnect the silicon tubing next to the two-way compression valve from the sample assembly. Connect the canister and flow controller using the installed compression nut.



5. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two canisters using stainless-steel duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample tee-fitting as illustrated below.



8.2 Sample Documentation

Record weather information at the beginning of each day of the sampling event at a minimum. If appropriate record weather information during the middle and end of each day of the sampling event. Use the weather function in the FieldNow® Standard – Vapor Intrusion Sampling Log application. If using a field sampling form contact the local airport or other suitable information source (e.g., weatherunderground.com, or NOAA) to obtain the following information:

- Wind speed and direction;
- Ambient temperature;
- Barometric pressure; and
- Relative humidity.

Record information on sample label tags on canister, on field sample log or in the FieldNow® Standard – Vapor Intrusion Sampling Log application, and COC. This includes:

- Canister number;
- Flow controller number;
- Sample ID;
- Start and end times; and
- Canister initial and final vacuum.

Take a photograph of the canister, completed canister tag, and surrounding area.

8.3 Sample Collection

At sub-slab ports, connect the sample train to the sub-slab port barb fitting with 1/4-inch ID silicone tubing. The two-way compression valve should be closed. Soil vapor probes are typically completed with all sample train components permanently connected and contained within the manway vault.

Sample collection consists of pre-sampling (i.e., shut-in test, 3-volume purge, and leak check) as well as sampling activities, discussed below. The procedures listed below for the 3-volume purge may also be used to conduct the post-installation purge of the soil vapor sampling point, which should be conducted within 24 to 48 hours following soil vapor sampling point installation, but includes additional calculated volume.

8.3.1 Shut-in Test and 3-Volume Purge

Conduct a shut-in test, 3-volume purge, and leak check prior to sampling. The shut-in test is conducted first, and then the 3-volume purge is completed concurrently with the leak check. The pre-sampling purge volume conducted immediately prior to sampling includes the internal volume of the tubing and sub-slab port or probe tip. The post-installation purge volume conducted immediately after installation includes the following:

- The internal volume of the tubing and probe;
- The void space of the sand pack around the probe; and
- The void space of the dry bentonite in the annular space.

Sample Train Purge Isolation Setup with Syringe

1. Set-up the helium leak test shroud or water dam test in accordance with applicable TGI, when necessary. Note, the water dam test can only be performed on sub-slab ports not soil vapor probes.
2. Perform a shut-in test or leak-down-test with the two-way compression valve closed to the sample port. Open the three-way valve to the syringe and slowly pull a vacuum at a rate no faster than 1 to 2 mL/second (approximately 60 to 120 mL/min). Quickly close the three-way valve and record the pressure indicated on the gauge.
3. Open the canister valve but do not open the two-way valve on the sample assembly.
4. Record the vacuum indicated on the gauge connected to the canister. Observe the vacuum gauge for at least two minutes and no longer than 10 minutes. If there are no leaks in the system, this vacuum should be held exactly (estimate the decimal place – i.e., 29.1 inches of Hg). Tap the gauge and wait to see if pressure drops on the gauge.
5. If vacuum holds, document values and proceed with purge by opening the two-way sample assembly valve. If not, attempt to rectify the situation by tightening fittings and restart shut-in test.
6. Purge approximately three volumes of air from the sample port and tubing using the syringe or personal air pump capable of rates of <200 mL/min into the Tedlar® bag using a flow rate <200 mL/min. Purge rate should not exceed 200 mL/min or 1 to 1.5 mL per second when using a syringe. Purge volume is calculated using the equation of V = $\pi^2 h$:

$$\textit{Purge volume} = 3 \times \pi \times \textit{inner radius of tubing}^2 \times \textit{length of tubing}$$

7. Purged air will be collected into a Tedlar® bag to so VOCs are not released into interior spaces or the sampler's breathing zone. Perform quality control method tests such as helium leak testing, water dam testing, and/or field screening for VOCs concurrently per the project-specific work plan.
8. Close the three-way valve to the syringe to isolate this leg of the sample train.

Sample Train Separate Purge/Sample Setup with Canister

1. Connect the three-way valve, syringe, and Tedlar bag to the sample train. Open the two-way compression valve and purge approximately three volumes of air from the sample port and tubing using the syringe or personal air pump capable of <200 mL/min into the Tedlar® bag using a flow rate <200 mL/min. Purge rate should not exceed 200 mL/min or 1 to 1.5 mL per second when using a syringe. Purge volume is calculated using the equation above.
2. Close the two-way compression valve and disconnect the syringe purge setup.
3. Connect the canister and flow controller to the sample train. Perform a shut-in test or leak-down-test by opening the canister valve but do not open the two-way valve on the sample assembly.
4. Record the vacuum indicated on the gauge connected to the canister. Observe the vacuum gauge for at least two minutes. If there are no leaks in the system, this vacuum should be held exactly (estimate the decimal place – i.e., 29.5 inches of Hg).
5. If vacuum holds, document values and proceed with sampling by opening the two-way sample assembly valve. If not, attempt to rectify the situation by tightening fittings and restart shut-in test.

8.3.2 Sampling

1. Open the canister valve to initiate sample collection. Record the start time and the initial canister vacuum on the sample log or FieldNow® application. The preference is a starting vacuum of -28 inches of Hg or more, but some canisters may be used in certain jurisdictions with lower starting vacuum. However, ff the initial vacuum registers less than -25 inches of Hg (-27 inches of Hg in Michigan), then the canister is not appropriate for use and another canister should be used. The initial vacuum required varies by jurisdiction; confirm with the project regulatory authority.
2. Check the canister approximately halfway through the sample duration and note progress on sample logs or FieldNow® application. If the vacuum decreases greater than a rate of 200 mL/min or the vacuum stops decreasing during sample collection contact the project team.

8.3.3 Termination of Sample Collection

1. Sampling canisters should not be left unattended. For example, a 1-liter canister will typically take approximately 5 to 30 minutes, so even brief inattention or distraction can mistakenly lead to the canister reaching 0 inches of Hg or water in the tubing damaging the equipment.
2. Record the final vacuum on the sample collection log or FieldNow® Standard – Vapor Intrusion Sampling Log app. Stop collecting the sample by closing the canister valve then the sample train valve. The canister should have a minimum amount of vacuum (approximately 5 inches of Hg or slightly greater). Check with the project team on final pressure requirements as these vary by region.
3. Record the date and local time (24-hour basis) of valve closing on the canister tag, sample collection log or FieldNow® Standard – Vapor Intrusion Sampling Log application, and COC form.
4. Refill the Tedlar® bag with purged air with enough air to fill the bag via the purge to pump or syringe. Connect the Tedlar® bag to the PID and record stabilized VOC concentration on sample collection log. Disconnect the PID then connect the methane meter to the Tedlar® bag. Make sure to activate the pump on the methane meter, if not automatically started once turned on, and then allow time for vapor to flow through the meter to collect readings. Record stabilized methane concentration readings on sample collection log.
5. Disconnect sample tubing from the sample port and replace any coverings or abandon as appropriate to mitigate tripping hazards.
6. Remove the flow controller from the canister, re-install the brass plug on the canister fitting, and tighten with the appropriate wrench. If the canister and flow controller were shipped pre-assembled from the laboratory do not disassemble; simply re-install the brass plug on the flow controller fitting.
7. Verify the appropriate forms and sample labels are filled out appropriately as directed by the laboratory (e.g., affix card with a string).
8. Package the canister and flow controller per DOT regulations for return shipment to the laboratory. These regulations can be found at the Transportation Safety Program's Team Site on the Source. The canister does not require preservation with ice or refrigeration during shipment. Refer to TGI – Soil Gas Methane Monitoring for Shipping Determination of Soil Gas Samples if sampling in an area with unknown or known methane conditions. A shipping determination form is required for shipment of any type of samples prior to field mobilization.
9. Complete and verify the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via overnight

carrier (e.g., Federal Express) or sign COC over to courier. Consult with the project team on appropriate shipping speeds and shipment insurance.

9 Waste Management

No specific waste management procedures are required.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

11 Quality Assurance

Quality assurance and quality control (QA/QC) will be conducted following project requirements.

11.1 Duplicate Samples

Duplicate samples should be collected in the field as a quality assurance step per project requirements. Generally, one duplicate is taken per 10 or per 20 samples analyzed, but project specific requirements should take precedence. A duplicate tee is required when collecting soil vapor duplicate samples.

11.2 Equipment Blank

Equipment blank samples may be collected in the field as a quality assurance step in order to verify and evaluate the effectiveness of decontamination procedures for new, recycled, or reused materials (i.e., syringes, Swagelok® fittings, 1/4-inch tubing) per project requirements. Generally, one equipment blank sample is taken per 20 sample locations, but project specific requirements should take precedence. Equipment blank sampling steps detailed below:

1. Connect decontaminated reusable sampling supplies, in line with a clean, laboratory provided soil vapor manifold and 1-liter canister to a laboratory provided nitrogen-filled canister.
2. Conduct a shut-in test as described in section 8.3.1. Please note: a 3-volume purge and leak test are not necessary for the equipment blank.
3. Collect a sample (generally following the steps from sections 8.3.2 and 8.4.3 using the nitrogen

canister as the vapor source. Gas collection readings from a PID and methane meter are not necessary for the equipment blank.

12 References

DiGiulio et. al. 2003. Draft Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA TO-15 to Support Vapor Intrusion Investigations. http://www.cdphe.state.co.us/hm/indoorair.pdf.

DiGiulio et. al. 2006. Assessment of Vapor intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples. USEPA. EPA/600/R-05/147.

USEPA. 1999a. Compendium Method TO-15. Determination of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information. Office of Research and Development. January.

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

New York State Department of Health (NYSDOH). 2005. DRAFT “Guidance for Evaluating Soil Vapor Intrusion in the State of New York” February 23, 2005.

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Attachment 3

Analytical Laboratory Reports

Analytical Laboratory Report

Report sample .20 only

Report ID: S78714.20(02)
Generated on 09/30/2025

Report to

Attention: Alexis Nickerson
Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S78714.20
Project: 30267726.00005
Collected Date(s): 09/10/2025
Submitted Date/Time: 09/10/2025 15:30
Sampled by: Jeremy Myers
P.O. #: 30267726.00005

Table of Contents

Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Starred (*) analytes are not NY NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.

Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.
All accreditations/certifications held by this laboratory are listed on page 3. Not all accreditations/certifications are applicable to this report.
For a specific list of accredited analytes, please feel free to contact the laboratory or visit https://www.meritlabs.com/certifications.

Report Narrative

Report samples .20 only per client request

Laboratory Accreditations (For Reference Only)

Authority	Accreditation ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699 PJLA Testing
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
o	Associated EIS outside of control limits
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
q	Qualifier ion ratio outside of control limits
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
N/A	Not Applicable
SW5030C/8260C	SW 846 Method 8260C Revision 3 August 2006 / 5030C Revision 3 May 2003

Sample Summary (1 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S78714.20	JS-MW-16_GW-091025	Groundwater	09/10/25 13:45

Lab Sample ID: S78714.20
Sample Tag: JS-MW-16_GW-091025
Collected Date/Time: 09/10/2025 13:45
Matrix: Groundwater
COC Reference: 187871

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
3	40mL Glass	HCL	Yes	4.2	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
pH check for VOCs*	<2	N/A	09/15/25 12:20	NDK	

Organics - Volatiles

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 09/15/25 18:27, Analyst: NDK

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Diethyl ether	Not detected	10		ug/L	1	60-29-7	
Acetone	Not detected	50		ug/L	1	67-64-1	
Methyl iodide	Not detected	1		ug/L	1	74-88-4	
Carbon disulfide	Not detected	5		ug/L	1	75-15-0	
tert-Methyl butyl ether (MTBE)	Not detected	5		ug/L	1	1634-04-4	
Acrylonitrile	Not detected	2		ug/L	1	107-13-1	
2-Butanone (MEK)	Not detected	25		ug/L	1	78-93-3	
Dichlorodifluoromethane	Not detected	5		ug/L	1	75-71-8	
Chloromethane	Not detected	5		ug/L	1	74-87-3	
Vinyl chloride	Not detected	1		ug/L	1	75-01-4	
Bromomethane	Not detected	5		ug/L	1	74-83-9	
Chloroethane	Not detected	5		ug/L	1	75-00-3	
Trichlorofluoromethane	Not detected	1		ug/L	1	75-69-4	
1,1-Dichloroethene	Not detected	1		ug/L	1	75-35-4	
Methylene chloride	Not detected	5		ug/L	1	75-09-2	
trans-1,2-Dichloroethene	Not detected	1		ug/L	1	156-60-5	
1,1-Dichloroethane	Not detected	1		ug/L	1	75-34-3	
cis-1,2-Dichloroethene	Not detected	1		ug/L	1	156-59-2	
Tetrahydrofuran	Not detected	90		ug/L	1	109-99-9	
Chloroform	Not detected	1		ug/L	1	67-66-3	
Bromochloromethane	Not detected	1		ug/L	1	74-97-5	
1,1,1-Trichloroethane	Not detected	1		ug/L	1	71-55-6	
4-Methyl-2-pentanone (MIBK)	Not detected	50		ug/L	1	108-10-1	
2-Hexanone	Not detected	50		ug/L	1	591-78-6	
Carbon tetrachloride	Not detected	1		ug/L	1	56-23-5	
Benzene	9	1		ug/L	1	71-43-2	
1,2-Dichloroethane	5	1		ug/L	1	107-06-2	
Trichloroethene	Not detected	1		ug/L	1	79-01-6	
1,2-Dichloropropane	Not detected	1		ug/L	1	78-87-5	
Bromodichloromethane	Not detected	1		ug/L	1	75-27-4	
Dibromomethane	Not detected	5		ug/L	1	74-95-3	
cis-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-01-5	
Toluene	1	1		ug/L	1	108-88-3	
trans-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-02-6	
1,1,2-Trichloroethane	Not detected	1		ug/L	1	79-00-5	
Tetrachloroethene	Not detected	1		ug/L	1	127-18-4	
trans-1,4-Dichloro-2-butene	Not detected	1		ug/L	1	110-57-6	

Lab Sample ID: S78714.20 (continued)
Sample Tag: JS-MW-16_GW-091025

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 09/15/25 18:27, Analyst: NDK (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibromochloromethane	Not detected	5		ug/L	1	124-48-1	
1,2-Dibromoethane	Not detected	1		ug/L	1	106-93-4	
Chlorobenzene	Not detected	1		ug/L	1	108-90-7	
1,1,1,2-Tetrachloroethane	Not detected	1		ug/L	1	630-20-6	
Ethylbenzene	Not detected	1		ug/L	1	100-41-4	
p,m-Xylene	32	2		ug/L	1		
o-Xylene	Not detected	1		ug/L	1	95-47-6	
Styrene	Not detected	1		ug/L	1	100-42-5	
Isopropylbenzene	5	5		ug/L	1	98-82-8	
Bromoform	Not detected	1		ug/L	1	75-25-2	
1,1,2,2-Tetrachloroethane	Not detected	1		ug/L	1	79-34-5	
1,2,3-Trichloropropane	Not detected	1		ug/L	1	96-18-4	
n-Propylbenzene	7	1		ug/L	1	103-65-1	
Bromobenzene	Not detected	1		ug/L	1	108-86-1	
1,3,5-Trimethylbenzene	Not detected	1		ug/L	1	108-67-8	
tert-Butylbenzene	Not detected	1		ug/L	1	98-06-6	
1,2,4-Trimethylbenzene	15	1		ug/L	1	95-63-6	
sec-Butylbenzene	Not detected	1		ug/L	1	135-98-8	
p-Isopropyltoluene	Not detected	5		ug/L	1	99-87-6	
1,3-Dichlorobenzene	Not detected	1		ug/L	1	541-73-1	
1,4-Dichlorobenzene	Not detected	1		ug/L	1	106-46-7	
1,2-Dichlorobenzene	Not detected	1		ug/L	1	95-50-1	
1,2,3-Trimethylbenzene	7	1		ug/L	1	526-73-8	
n-Butylbenzene	Not detected	1		ug/L	1	104-51-8	
Hexachloroethane	Not detected	5		ug/L	1	67-72-1	
1,2-Dibromo-3-chloropropane	Not detected	5		ug/L	1	96-12-8	
1,2,4-Trichlorobenzene	Not detected	5		ug/L	1	120-82-1	
1,2,3-Trichlorobenzene	Not detected	5		ug/L	1	87-61-6	
Naphthalene	Not detected	5		ug/L	1	91-20-3	
2-Methylnaphthalene	Not detected	5		ug/L	1	91-57-6	

Merit Laboratories Login Checklist

Lab Set ID: S78714
Client: ARCADIS_NOVI (ARCADIS U.S., Inc.)
Project: 30267726.00005
Submitted: 09/10/2025 15:30 Login User: MMC

Attention: Alexis Nickerson
Address: Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 4.2
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[X] No	[ ] N/A	Do water VOC, TOX, DO or Alkalinity bottles contain	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories, Inc.
2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # 1 OF 2

187869

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Alexis Nickerson
COMPANY: Arcadis
ADDRESS: 28550 Cabot Dr #500
CITY: Novi STATE: MI ZIP CODE: 48377
PHONE NO.: 614-985-9163 CELL NO.: P.O. NO.:
E-MAIL ADDRESS: tiffany.linder@arcadis.com alexis.nickerson@arcadis.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Accounts Payable ☐ SAME
COMPANY: Arcadis
ADDRESS: 630 Plaza Drive #600
CITY: Highlands Ranch STATE: CO ZIP CODE: 80129
PHONE NO.: E-MAIL ADDRESS: accountspayable.administration@arcadis

PROJECT NO./NAME: 30267726.00005
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Jeremy Myers

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER

DELIVERABLES REQUIRED ☒ LEVEL II ☐ LEVEL III ☒ LEVEL IV ☒ EDD ☐ OTHER

MATRIX CODE: W=WATER GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR WS=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES
Project Locations: ☐ Detroit ☐ New York ☐ Other
Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	COLLECTION DATE	COLLECTION TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Full List VOCs, 8260	Special Instructions
7874.01	09/09/25	16:15	MW-06-20_GW-090825	GW	3		X						X	
.02	09/09/25	9:45	MW-11-22_GW-090925	GW	3		X						X	
.03	09/09/25	10:40	MWF16-23_GW-090925	GW	3		X						X	
.04	09/09/25	11:30	MW-05-18_GW-090925	GW	3		X						X	
.05	09/09/25	12:20	MW-07-20_GW-090925	GW	3		X						X	
.06	09/09/25	13:15	MWF16-07_GW-090925	GW	3		X						X	
.07	09/09/25	14:05	UNKNOWN-01_GW-090925	GW	3		X						X	
.08	—	—	TRIP BLANK	W	1		X						X	Trip Blank

RELINQUISHED BY: SIGNATURE/ORGANIZATION: J. Myers Arcadis ☐ Sampler DATE: 09/09/25 TIME: 14:30
RECEIVED BY: SIGNATURE/ORGANIZATION: Lottie Jay/Lottiejay/ARCADIS DATE: 9/9/25 TIME: 1430

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Lottie Jay/Lottiejay/ARCADIS DATE: 9/10/25 TIME: 1404
RECEIVED BY: SIGNATURE/ORGANIZATION: DATE: 9/10/25 TIME: 1404

RELINQUISHED BY: SIGNATURE/ORGANIZATION: DATE: 9/10/25 TIME: 1537
RECEIVED BY: SIGNATURE/ORGANIZATION: M Dilcoo DATE: 9/10/25 TIME: 1530

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

☒ ICE (SOLID) ☐ ICE (MELTED) ☐ BLUE ICE ☐ NONE
TEMP. ON ARRIVAL: 4.2

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 02/25

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # 2 OF 2

187871

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Alexis Nickerson
COMPANY: ARCADIS
ADDRESS: 28550 Cabot Dr #500
CITY: Novi STATE: MI ZIP CODE: 48377
PHONE NO.: 614-985-9163 CELL NO.: P.O. NO.:
E-MAIL ADDRESS: Tiffany.Linder@arcadis.com & Alexis.Nickerson@arcadis.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Accounts Payable ☐ SAME
COMPANY: ARCADIS
ADDRESS: 630 Plaza Dr #600
CITY: Highlands Ranch STATE: CO ZIP CODE: 80129
PHONE NO.: E-MAIL ADDRESS: accountspayable.administration@arcadis.com

PROJECT NO./NAME: 30267726.00005/Racer PNC
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Lottie Jay / Lottie Jay

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER

DELIVERABLES REQUIRED ☒ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☒ EDD ☐ OTHER

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ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES
Project Locations
☐ Detroit ☐ New York
☐ Other
Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	COLLECTION DATE	COLLECTION TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Full VOCs via method 8260	Special Instructions
78714.09	9/8/25	1626	MW-08-21_GW-090825	GW	3		3						X	
.10	9/9/25	1018	MW05-08_GW-090925	GW	3		3						X	
.11/.12/.13	9/9/25	1119	MW-02-17_GW-090925	GW	9		9						X	Run MS/MSD
.14	9/9/25	1233	MW-16-22_GW-090925	GW	3		3						X	
.15	9/9/25	1353	MWF16-15_GW-090925	GW	3		3						X	
.16	9/9/25	—	DUP-03_GW-090925	GW	3		3						X	
.17/.18/.19	9/10/25	1157	MWF15-01_GW-091025	GW	9		9						X	Run MS/MSD
.20	9/10/25	1345	JS-MW-16_GW-091025	GW	3		3						X	

(15) 9/10/25

(15) 9/10/25

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Lottie Jay / Lottie Jay ☒ Sampler DATE: 9/10/25 TIME: 1404
RECEIVED BY: SIGNATURE/ORGANIZATION: DWS DATE: 9/10/25 TIME: 14:02
RELINQUISHED BY: SIGNATURE/ORGANIZATION: DATE: 9/10/25 TIME: 15:30
RECEIVED BY: SIGNATURE/ORGANIZATION: M Calcote DATE: 9/10/25 TIME: 1530

RELINQUISHED BY: SIGNATURE/ORGANIZATION: DATE: TIME:
RECEIVED BY: SIGNATURE/ORGANIZATION: DATE: TIME:

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

☒ ICE (SOLID) ☐ ICE (MELTED) ☐ BLUE ICE ☐ NONE TEMP. ON ARRIVAL 4.2

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 02/25

Analytical Laboratory Report

Report sample .01 only

Report ID: S78763.01(03)
Generated on 09/30/2025

Report to

Attention: Alexis Nickerson
Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Addtional Contacts: Tiffany Linder

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S78763.01
Project: 30267726.00005 / RACER PNC
Collected Date(s): 09/10/2025
Submitted Date/Time: 09/11/2025 16:10
Sampled by: Lottie Jay
P.O. #: 30267726.00005

Table of Contents

Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Starred (*) analytes are not NY NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.

Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.
All accreditations/certifications held by this laboratory are listed on page 3. Not all accreditations/certifications are applicable to this report.
For a specific list of accredited analytes, please feel free to contact the laboratory or visit https://www.meritlabs.com/certifications.

Report Narrative

Report sample .01 only

Laboratory Accreditations (For Reference Only)

Authority	Accreditation ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699 PJLA Testing
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
o	Associated EIS outside of control limits
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
q	Qualifier ion ratio outside of control limits
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
N/A	Not Applicable
SW5030C/8260C	SW 846 Method 8260C Revision 3 August 2006 / 5030C Revision 3 May 2003

Sample Summary (1 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S78763.01	JS-MW-19_GW091025	Groundwater	09/10/25 15:32

Lab Sample ID: S78763.01
Sample Tag: JS-MW-19_GW091025
Collected Date/Time: 09/10/2025 15:32
Matrix: Groundwater
COC Reference: 187770

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
3	40mL Glass	HCL	Yes	5.1	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
pH check for VOCs*	<2	N/A	09/15/25 12:20	NDK	

Organics - Volatiles

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 09/13/25 07:57, Analyst: KAG

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Diethyl ether	Not detected	10		ug/L	1	60-29-7	
Acetone	Not detected	50		ug/L	1	67-64-1	
Methyl iodide	Not detected	1		ug/L	1	74-88-4	
Carbon disulfide	Not detected	5		ug/L	1	75-15-0	
tert-Methyl butyl ether (MTBE)	Not detected	5		ug/L	1	1634-04-4	
Acrylonitrile	Not detected	2		ug/L	1	107-13-1	
2-Butanone (MEK)	Not detected	25		ug/L	1	78-93-3	
Dichlorodifluoromethane	Not detected	5		ug/L	1	75-71-8	
Chloromethane	Not detected	5		ug/L	1	74-87-3	
Vinyl chloride	Not detected	1		ug/L	1	75-01-4	
Bromomethane	Not detected	5		ug/L	1	74-83-9	
Chloroethane	Not detected	5		ug/L	1	75-00-3	
Trichlorofluoromethane	Not detected	1		ug/L	1	75-69-4	
1,1-Dichloroethene	Not detected	1		ug/L	1	75-35-4	
Methylene chloride	Not detected	5		ug/L	1	75-09-2	
trans-1,2-Dichloroethene	Not detected	1		ug/L	1	156-60-5	
1,1-Dichloroethane	Not detected	1		ug/L	1	75-34-3	
cis-1,2-Dichloroethene	Not detected	1		ug/L	1	156-59-2	
Tetrahydrofuran	Not detected	90		ug/L	1	109-99-9	
Chloroform	Not detected	1		ug/L	1	67-66-3	
Bromochloromethane	Not detected	1		ug/L	1	74-97-5	
1,1,1-Trichloroethane	Not detected	1		ug/L	1	71-55-6	
4-Methyl-2-pentanone (MIBK)	Not detected	50		ug/L	1	108-10-1	
2-Hexanone	Not detected	50		ug/L	1	591-78-6	
Carbon tetrachloride	Not detected	1		ug/L	1	56-23-5	
Benzene	Not detected	1		ug/L	1	71-43-2	
1,2-Dichloroethane	Not detected	1		ug/L	1	107-06-2	
Trichloroethene	Not detected	1		ug/L	1	79-01-6	
1,2-Dichloropropane	Not detected	1		ug/L	1	78-87-5	
Bromodichloromethane	Not detected	1		ug/L	1	75-27-4	
Dibromomethane	Not detected	5		ug/L	1	74-95-3	
cis-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-01-5	
Toluene	Not detected	1		ug/L	1	108-88-3	
trans-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-02-6	
1,1,2-Trichloroethane	Not detected	1		ug/L	1	79-00-5	
Tetrachloroethene	Not detected	1		ug/L	1	127-18-4	
trans-1,4-Dichloro-2-butene	Not detected	1		ug/L	1	110-57-6	

Lab Sample ID: S78763.01 (continued)
Sample Tag: JS-MW-19_GW091025

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 09/13/25 07:57, Analyst: KAG (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibromochloromethane	Not detected	5		ug/L	1	124-48-1	
1,2-Dibromoethane	Not detected	1		ug/L	1	106-93-4	
Chlorobenzene	Not detected	1		ug/L	1	108-90-7	
1,1,1,2-Tetrachloroethane	Not detected	1		ug/L	1	630-20-6	
Ethylbenzene	Not detected	1		ug/L	1	100-41-4	
p,m-Xylene	Not detected	2		ug/L	1		
o-Xylene	Not detected	1		ug/L	1	95-47-6	
Styrene	Not detected	1		ug/L	1	100-42-5	
Isopropylbenzene	Not detected	5		ug/L	1	98-82-8	
Bromoform	Not detected	1		ug/L	1	75-25-2	
1,1,2,2-Tetrachloroethane	Not detected	1		ug/L	1	79-34-5	
1,2,3-Trichloropropane	Not detected	1		ug/L	1	96-18-4	
n-Propylbenzene	Not detected	1		ug/L	1	103-65-1	
Bromobenzene	Not detected	1		ug/L	1	108-86-1	
1,3,5-Trimethylbenzene	Not detected	1		ug/L	1	108-67-8	
tert-Butylbenzene	Not detected	1		ug/L	1	98-06-6	
1,2,4-Trimethylbenzene	Not detected	1		ug/L	1	95-63-6	
sec-Butylbenzene	Not detected	1		ug/L	1	135-98-8	
p-Isopropyltoluene	Not detected	5		ug/L	1	99-87-6	
1,3-Dichlorobenzene	Not detected	1		ug/L	1	541-73-1	
1,4-Dichlorobenzene	Not detected	1		ug/L	1	106-46-7	
1,2-Dichlorobenzene	Not detected	1		ug/L	1	95-50-1	
1,2,3-Trimethylbenzene	Not detected	1		ug/L	1	526-73-8	
n-Butylbenzene	Not detected	1		ug/L	1	104-51-8	
Hexachloroethane	Not detected	5		ug/L	1	67-72-1	
1,2-Dibromo-3-chloropropane	Not detected	5		ug/L	1	96-12-8	
1,2,4-Trichlorobenzene	Not detected	5		ug/L	1	120-82-1	
1,2,3-Trichlorobenzene	Not detected	5		ug/L	1	87-61-6	
Naphthalene	Not detected	5		ug/L	1	91-20-3	
2-Methylnaphthalene	Not detected	5		ug/L	1	91-57-6	

Merit Laboratories Login Checklist

Lab Set ID: S78763
Client: ARCADIS_NOVI (ARCADIS U.S., Inc.)
Project: 30267726.00005 / RACER PNC
Submitted: 09/11/2025 16:10 Login User: PFD

Attention: Alexis Nickerson
Address: Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 5.1
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[X] No	[ ] N/A	Do water VOC, TOX, DO or Alkalinity bottles contain	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # _____ OF _____

187770

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Alexis Nickerson
COMPANY: ARCADIS
ADDRESS: 28550 Cabot Dr #500
CITY: Novi STATE: MI ZIP CODE: 48377
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COMPANY: ARCADIS
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PHONE NO.: E-MAIL ADDRESS: accountspayable.administration@arcadis.com

PROJECT NO./NAME: 30267726.00005 / Racer PNC
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Lottie Jay Lottie Jay

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____

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ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES

Project Locations
☐ Detroit ☐ New York
☐ Other _____

Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	COLLECTION DATE	COLLECTION TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	List Full VOCs via method 8260
1876301	9/10/25	1532	JS-MW-19_GW-091025	GW	3		3	X					X
.02	9/11/25	0956	MWF16-06_GW-091125	GW	3		3						X
.03	9/11/25	1235	MWF16-05_GW-091125	GW	3		3						X
.04	9/11/25	1250	MWF16-12_GW-091125	GW	3		3						X
.05	9/11/25	1354	MWF16-17_GW-091125	GW	3		3						X
06	9/11/25	—	DUP-02_GW-091125	GW	3		3						X
07	—	—	Trip Blank	W	1		1						X

W 9/11/25 W 9/11/25

RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
Lottie Jay / Lottie Jay	☒ Sampler	9/11/25	1445
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
		9/11/25	1454
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
		9/11/25	1610
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
		9/11/25	1610

RELINQUISHED BY: SIGNATURE/ORGANIZATION	DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION	DATE	TIME

SEAL NO.	SEAL INTACT YES ☐ NO ☐	INITIALS
SEAL NO.	SEAL INTACT YES ☐ NO ☐	INITIALS

☒ ICE (SOLID) ☐ BLUE ICE ☐ ICE (MELTED) ☐ NONE

TEMP. ON ARRIVAL: 5.1

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 02/25

Analytical Laboratory Report

Report sample .01 only

Report ID: S78766.01(02)
Generated on 09/30/2025

Report to

Attention: Alexis Nickerson
Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Addtional Contacts: Tiffany Linder

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S78766.01
Project: 30267726.00005 / RACER PNC
Collected Date(s): 09/10/2025
Submitted Date/Time: 09/11/2025 16:10
Sampled by: Jeremy Myers
P.O. #: 30267726.00005

Table of Contents

Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Starred (*) analytes are not NY NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.

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PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.
All accreditations/certifications held by this laboratory are listed on page 3. Not all accreditations/certifications are applicable to this report.
For a specific list of accredited analytes, please feel free to contact the laboratory or visit https://www.meritlabs.com/certifications.

Report Narrative

Report sample .01 only per client request

Laboratory Accreditations (For Reference Only)

Authority	Accreditation ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699 PJLA Testing
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
o	Associated EIS outside of control limits
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
q	Qualifier ion ratio outside of control limits
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
N/A	Not Applicable
SW5030C/8260C	SW 846 Method 8260C Revision 3 August 2006 / 5030C Revision 3 May 2003

Sample Summary (1 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S78766.01	JS-MW-06_GW-091025	Groundwater	09/10/25 15:40

Lab Sample ID: S78766.01
Sample Tag: JS-MW-06_GW-091025
Collected Date/Time: 09/10/2025 15:40
Matrix: Groundwater
COC Reference: 187769

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
3	40mL Glass	HCL	Yes	5.1	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
pH check for VOCs*	<2	N/A	09/15/25 12:20	NDK	

Organics - Volatiles

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 09/13/25 04:17, Analyst: KAG

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Diethyl ether	Not detected	10		ug/L	1	60-29-7	
Acetone	Not detected	50		ug/L	1	67-64-1	
Methyl iodide	Not detected	1		ug/L	1	74-88-4	
Carbon disulfide	Not detected	5		ug/L	1	75-15-0	
tert-Methyl butyl ether (MTBE)	Not detected	5		ug/L	1	1634-04-4	
Acrylonitrile	Not detected	2		ug/L	1	107-13-1	
2-Butanone (MEK)	Not detected	25		ug/L	1	78-93-3	
Dichlorodifluoromethane	Not detected	5		ug/L	1	75-71-8	
Chloromethane	Not detected	5		ug/L	1	74-87-3	
Vinyl chloride	Not detected	1		ug/L	1	75-01-4	
Bromomethane	Not detected	5		ug/L	1	74-83-9	
Chloroethane	Not detected	5		ug/L	1	75-00-3	
Trichlorofluoromethane	Not detected	1		ug/L	1	75-69-4	
1,1-Dichloroethene	Not detected	1		ug/L	1	75-35-4	
Methylene chloride	Not detected	5		ug/L	1	75-09-2	
trans-1,2-Dichloroethene	Not detected	1		ug/L	1	156-60-5	
1,1-Dichloroethane	Not detected	1		ug/L	1	75-34-3	
cis-1,2-Dichloroethene	Not detected	1		ug/L	1	156-59-2	
Tetrahydrofuran	Not detected	90		ug/L	1	109-99-9	
Chloroform	Not detected	1		ug/L	1	67-66-3	
Bromochloromethane	Not detected	1		ug/L	1	74-97-5	
1,1,1-Trichloroethane	Not detected	1		ug/L	1	71-55-6	
4-Methyl-2-pentanone (MIBK)	Not detected	50		ug/L	1	108-10-1	
2-Hexanone	Not detected	50		ug/L	1	591-78-6	
Carbon tetrachloride	Not detected	1		ug/L	1	56-23-5	
Benzene	Not detected	1		ug/L	1	71-43-2	
1,2-Dichloroethane	Not detected	1		ug/L	1	107-06-2	
Trichloroethene	Not detected	1		ug/L	1	79-01-6	
1,2-Dichloropropane	Not detected	1		ug/L	1	78-87-5	
Bromodichloromethane	Not detected	1		ug/L	1	75-27-4	
Dibromomethane	Not detected	5		ug/L	1	74-95-3	
cis-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-01-5	
Toluene	Not detected	1		ug/L	1	108-88-3	
trans-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-02-6	
1,1,2-Trichloroethane	Not detected	1		ug/L	1	79-00-5	
Tetrachloroethene	Not detected	1		ug/L	1	127-18-4	
trans-1,4-Dichloro-2-butene	Not detected	1		ug/L	1	110-57-6	

Lab Sample ID: S78766.01 (continued)
Sample Tag: JS-MW-06_GW-091025

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 09/13/25 04:17, Analyst: KAG (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibromochloromethane	Not detected	5		ug/L	1	124-48-1	
1,2-Dibromoethane	Not detected	1		ug/L	1	106-93-4	
Chlorobenzene	Not detected	1		ug/L	1	108-90-7	
1,1,1,2-Tetrachloroethane	Not detected	1		ug/L	1	630-20-6	
Ethylbenzene	Not detected	1		ug/L	1	100-41-4	
p,m-Xylene	Not detected	2		ug/L	1		
o-Xylene	Not detected	1		ug/L	1	95-47-6	
Styrene	Not detected	1		ug/L	1	100-42-5	
Isopropylbenzene	Not detected	5		ug/L	1	98-82-8	
Bromoform	Not detected	1		ug/L	1	75-25-2	
1,1,2,2-Tetrachloroethane	Not detected	1		ug/L	1	79-34-5	
1,2,3-Trichloropropane	Not detected	1		ug/L	1	96-18-4	
n-Propylbenzene	Not detected	1		ug/L	1	103-65-1	
Bromobenzene	Not detected	1		ug/L	1	108-86-1	
1,3,5-Trimethylbenzene	Not detected	1		ug/L	1	108-67-8	
tert-Butylbenzene	Not detected	1		ug/L	1	98-06-6	
1,2,4-Trimethylbenzene	Not detected	1		ug/L	1	95-63-6	
sec-Butylbenzene	Not detected	1		ug/L	1	135-98-8	
p-Isopropyltoluene	Not detected	5		ug/L	1	99-87-6	
1,3-Dichlorobenzene	Not detected	1		ug/L	1	541-73-1	
1,4-Dichlorobenzene	Not detected	1		ug/L	1	106-46-7	
1,2-Dichlorobenzene	Not detected	1		ug/L	1	95-50-1	
1,2,3-Trimethylbenzene	Not detected	1		ug/L	1	526-73-8	
n-Butylbenzene	Not detected	1		ug/L	1	104-51-8	
Hexachloroethane	Not detected	5		ug/L	1	67-72-1	
1,2-Dibromo-3-chloropropane	Not detected	5		ug/L	1	96-12-8	
1,2,4-Trichlorobenzene	Not detected	5		ug/L	1	120-82-1	
1,2,3-Trichlorobenzene	Not detected	5		ug/L	1	87-61-6	
Naphthalene	Not detected	5		ug/L	1	91-20-3	
2-Methylnaphthalene	Not detected	5		ug/L	1	91-57-6	

Merit Laboratories Login Checklist

Lab Set ID: S78766
Client: ARCADIS_NOVI (ARCADIS U.S., Inc.)
Project: 30267726.00005 / RACER PNC
Submitted: 09/11/2025 16:10 Login User: PFD

Attention: Alexis Nickerson
Address: Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 5.1
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[X] No	[ ] N/A	Do water VOC, TOX, DO or Alkalinity bottles contain	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # _____ OF _____

187769

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Alexis Nickerson
COMPANY: Arcadis
ADDRESS: 28550 Cabot Dr # 500
CITY: Novi STATE: MI ZIP CODE: 48377
PHONE NO.: 614-985-9163 CELL NO.: P.O. NO.:
E-MAIL ADDRESS: Tiffany.Linder@arcadis.com; alexis.nickerson@arcadis.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Accounts Payable ☐ SAME
COMPANY: Arcadis
ADDRESS: 630 Plaza Dr #600
CITY: Highlands Ranch STATE: CO ZIP CODE: 80129
PHONE NO.: E-MAIL ADDRESS: accounts payable.administration@arcadis.com

PROJECT NO./NAME: 30267726.00005
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Jeremy Mews

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____

DELIVERABLES REQUIRED ☐ LEVEL II ☒ LEVEL III ☐ LEVEL IV ☒ EDD ☐ OTHER _____

MATRIX CODE: W=WATER GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR WS=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES

Project Locations: ☐ Detroit ☐ New York ☐ Other _____

Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	COLLECTION DATE	COLLECTION TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Full VOCs via Method 8260
787601	09/10/25	15:40	SS-MW-06_GW-091025	GW	3		X						X
.02	09/11/25	9:20	MWF16-18_GW-091125	GW	3		X						X
.03	09/11/25	10:05	MW-09-22_GW-091125	GW	3		X						X
.04	09/11/25	11:00	MWF16-22_GW-091125	GW	3		X						X
.05	09/11/25	12:20	TW-12-22_GW-091125	GW	3		X						X
.06	09/11/25	13:15	MWF16-16_GW-091125	GW	3		X						X
.07	09/11/25	—	DUP-01_GW-091125	GW	3		X						X

RELINQUISHED BY: SIGNATURE/ORGANIZATION	ARCADIS J. Mews ☒ Sampler	DATE 09/11/25	TIME 14:45
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE 9/11/25	TIME 14:45
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE 9/11/25	TIME 16:10
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE 9/11/25	TIME 16:10

RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME

SEAL NO. _____ SEAL INTACT YES ☐ NO ☐ INITIALS _____
SEAL NO. _____ SEAL INTACT YES ☐ NO ☐ INITIALS _____

☐ ICE (SOLID) ☐ BLUE ICE ☐ ICE (MELTED) ☐ NONE

TEMP. ON ARRIVAL: 5.1

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 02/25

Analytical Laboratory Report

Report ID: S82318.01(01)
Generated on 12/15/2025

Report to

Attention: Alexis Nickerson
Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S82318.01-S82318.02
Project: 30267726.00005 / RACER PNC
Collected Date(s): 12/11/2025
Submitted Date/Time: 12/11/2025 15:50
Sampled by: Lottie Jay
P.O. #: 30267726.00005

Table of Contents

Maya Murshak
Technical Director

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Report Narrative

There is no additional narrative for this analytical report

Laboratory Accreditations (For Reference Only)

Authority	Accreditation ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699 PJLA Testing
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

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B	Compound also found in associated method blank
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J	Estimated value less than reporting limit, but greater than MDL
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M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
o	Associated EIS outside of control limits
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
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Glossary of Abbreviations

Abbreviation	Description
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MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
N/A	Not Applicable
SW5030C/8260C	SW 846 Method 8260C Revision 3 August 2006 / 5030C Revision 3 May 2003

Analytical Laboratory Report

Sample Summary (2 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S82318.01	JS-MW-16-GW_121125	Groundwater	12/11/25 14:16
S82318.02	DUP-01_GW-121125	Groundwater	12/11/25 00:01

Lab Sample ID: S82318.01
Sample Tag: JS-MW-16-GW_121125
Collected Date/Time: 12/11/2025 14:16
Matrix: Groundwater
COC Reference: 188872

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
3	40mL Glass	HCL	Yes	4.9	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
pH check for VOCs*	<2	N/A	12/15/25 10:45	BDO	

Organics - Volatiles

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 12/13/25 06:59, Analyst: NDK

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Diethyl ether	Not detected	10		ug/L	1	60-29-7	
Acetone	Not detected	50		ug/L	1	67-64-1	
Methyl iodide	Not detected	1		ug/L	1	74-88-4	
Carbon disulfide	Not detected	5		ug/L	1	75-15-0	
tert-Methyl butyl ether (MTBE)	Not detected	5		ug/L	1	1634-04-4	
Acrylonitrile	Not detected	2		ug/L	1	107-13-1	
2-Butanone (MEK)	Not detected	25		ug/L	1	78-93-3	
Dichlorodifluoromethane	Not detected	5		ug/L	1	75-71-8	
Chloromethane	Not detected	5		ug/L	1	74-87-3	
Vinyl chloride	Not detected	1		ug/L	1	75-01-4	
Bromomethane	Not detected	5		ug/L	1	74-83-9	
Chloroethane	Not detected	5		ug/L	1	75-00-3	
Trichlorofluoromethane	Not detected	1		ug/L	1	75-69-4	
1,1-Dichloroethene	Not detected	1		ug/L	1	75-35-4	
Methylene chloride	Not detected	5		ug/L	1	75-09-2	
trans-1,2-Dichloroethene	Not detected	1		ug/L	1	156-60-5	
1,1-Dichloroethane	Not detected	1		ug/L	1	75-34-3	
cis-1,2-Dichloroethene	Not detected	1		ug/L	1	156-59-2	
Tetrahydrofuran	Not detected	90		ug/L	1	109-99-9	
Chloroform	Not detected	1		ug/L	1	67-66-3	
Bromochloromethane	Not detected	1		ug/L	1	74-97-5	
1,1,1-Trichloroethane	Not detected	1		ug/L	1	71-55-6	
4-Methyl-2-pentanone (MIBK)	Not detected	50		ug/L	1	108-10-1	
2-Hexanone	Not detected	50		ug/L	1	591-78-6	
Carbon tetrachloride	Not detected	1		ug/L	1	56-23-5	
Benzene	2	1		ug/L	1	71-43-2	
1,2-Dichloroethane	7	1		ug/L	1	107-06-2	
Trichloroethene	Not detected	1		ug/L	1	79-01-6	
1,2-Dichloropropane	Not detected	1		ug/L	1	78-87-5	
Bromodichloromethane	Not detected	1		ug/L	1	75-27-4	
Dibromomethane	Not detected	5		ug/L	1	74-95-3	
cis-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-01-5	
Toluene	Not detected	1		ug/L	1	108-88-3	
trans-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-02-6	
1,1,2-Trichloroethane	Not detected	1		ug/L	1	79-00-5	
Tetrachloroethene	Not detected	1		ug/L	1	127-18-4	
trans-1,4-Dichloro-2-butene	Not detected	1		ug/L	1	110-57-6	

Lab Sample ID: S82318.01 (continued)
Sample Tag: JS-MW-16-GW_121125

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 12/13/25 06:59, Analyst: NDK (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibromochloromethane	Not detected	5		ug/L	1	124-48-1	
1,2-Dibromoethane	Not detected	1		ug/L	1	106-93-4	
Chlorobenzene	Not detected	1		ug/L	1	108-90-7	
1,1,1,2-Tetrachloroethane	Not detected	1		ug/L	1	630-20-6	
Ethylbenzene	Not detected	1		ug/L	1	100-41-4	
p,m-Xylene	12	2		ug/L	1	179601-23-1	
o-Xylene	Not detected	1		ug/L	1	95-47-6	
Styrene	Not detected	1		ug/L	1	100-42-5	
Isopropylbenzene	Not detected	5		ug/L	1	98-82-8	
Bromoform	Not detected	1		ug/L	1	75-25-2	
1,1,2,2-Tetrachloroethane	Not detected	1		ug/L	1	79-34-5	
1,2,3-Trichloropropane	Not detected	1		ug/L	1	96-18-4	
n-Propylbenzene	3	1		ug/L	1	103-65-1	
Bromobenzene	Not detected	1		ug/L	1	108-86-1	
1,3,5-Trimethylbenzene	Not detected	1		ug/L	1	108-67-8	
tert-Butylbenzene	Not detected	1		ug/L	1	98-06-6	
1,2,4-Trimethylbenzene	5	1		ug/L	1	95-63-6	
sec-Butylbenzene	Not detected	1		ug/L	1	135-98-8	
p-Isopropyltoluene	Not detected	5		ug/L	1	99-87-6	
1,3-Dichlorobenzene	Not detected	1		ug/L	1	541-73-1	
1,4-Dichlorobenzene	Not detected	1		ug/L	1	106-46-7	
1,2-Dichlorobenzene	Not detected	1		ug/L	1	95-50-1	
1,2,3-Trimethylbenzene	2	1		ug/L	1	526-73-8	
n-Butylbenzene	Not detected	1		ug/L	1	104-51-8	
Hexachloroethane	Not detected	5		ug/L	1	67-72-1	
1,2-Dibromo-3-chloropropane	Not detected	5		ug/L	1	96-12-8	
1,2,4-Trichlorobenzene	Not detected	5		ug/L	1	120-82-1	
1,2,3-Trichlorobenzene	Not detected	5		ug/L	1	87-61-6	
Naphthalene	Not detected	5		ug/L	1	91-20-3	
2-Methylnaphthalene	Not detected	5		ug/L	1	91-57-6	

Lab Sample ID: S82318.02
Sample Tag: DUP-01_GW-121125
Collected Date/Time: 12/11/2025 00:01
Matrix: Groundwater
COC Reference: 188872

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
3	40mL Glass	HCL	Yes	4.9	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
pH check for VOCs*	<2	N/A	12/15/25 10:45	BDO	

Organics - Volatiles

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 12/13/25 07:22, Analyst: NDK

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Diethyl ether	Not detected	10		ug/L	1	60-29-7	
Acetone	Not detected	50		ug/L	1	67-64-1	
Methyl iodide	Not detected	1		ug/L	1	74-88-4	
Carbon disulfide	Not detected	5		ug/L	1	75-15-0	
tert-Methyl butyl ether (MTBE)	Not detected	5		ug/L	1	1634-04-4	
Acrylonitrile	Not detected	2		ug/L	1	107-13-1	
2-Butanone (MEK)	Not detected	25		ug/L	1	78-93-3	
Dichlorodifluoromethane	Not detected	5		ug/L	1	75-71-8	
Chloromethane	Not detected	5		ug/L	1	74-87-3	
Vinyl chloride	Not detected	1		ug/L	1	75-01-4	
Bromomethane	Not detected	5		ug/L	1	74-83-9	
Chloroethane	Not detected	5		ug/L	1	75-00-3	
Trichlorofluoromethane	Not detected	1		ug/L	1	75-69-4	
1,1-Dichloroethene	Not detected	1		ug/L	1	75-35-4	
Methylene chloride	Not detected	5		ug/L	1	75-09-2	
trans-1,2-Dichloroethene	Not detected	1		ug/L	1	156-60-5	
1,1-Dichloroethane	Not detected	1		ug/L	1	75-34-3	
cis-1,2-Dichloroethene	Not detected	1		ug/L	1	156-59-2	
Tetrahydrofuran	Not detected	90		ug/L	1	109-99-9	
Chloroform	Not detected	1		ug/L	1	67-66-3	
Bromochloromethane	Not detected	1		ug/L	1	74-97-5	
1,1,1-Trichloroethane	Not detected	1		ug/L	1	71-55-6	
4-Methyl-2-pentanone (MIBK)	Not detected	50		ug/L	1	108-10-1	
2-Hexanone	Not detected	50		ug/L	1	591-78-6	
Carbon tetrachloride	Not detected	1		ug/L	1	56-23-5	
Benzene	2	1		ug/L	1	71-43-2	
1,2-Dichloroethane	7	1		ug/L	1	107-06-2	
Trichloroethene	Not detected	1		ug/L	1	79-01-6	
1,2-Dichloropropane	Not detected	1		ug/L	1	78-87-5	
Bromodichloromethane	Not detected	1		ug/L	1	75-27-4	
Dibromomethane	Not detected	5		ug/L	1	74-95-3	
cis-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-01-5	
Toluene	Not detected	1		ug/L	1	108-88-3	
trans-1,3-Dichloropropene	Not detected	1		ug/L	1	10061-02-6	
1,1,2-Trichloroethane	Not detected	1		ug/L	1	79-00-5	
Tetrachloroethene	Not detected	1		ug/L	1	127-18-4	
trans-1,4-Dichloro-2-butene	Not detected	1		ug/L	1	110-57-6	

Lab Sample ID: S82318.02 (continued)
Sample Tag: DUP-01_GW-121125

Volatile Organics - DEQ List, Method: SW5030C/8260C, Run Date: 12/13/25 07:22, Analyst: NDK (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibromochloromethane	Not detected	5		ug/L	1	124-48-1	
1,2-Dibromoethane	Not detected	1		ug/L	1	106-93-4	
Chlorobenzene	Not detected	1		ug/L	1	108-90-7	
1,1,1,2-Tetrachloroethane	Not detected	1		ug/L	1	630-20-6	
Ethylbenzene	Not detected	1		ug/L	1	100-41-4	
p,m-Xylene	12	2		ug/L	1	179601-23-1	
o-Xylene	Not detected	1		ug/L	1	95-47-6	
Styrene	Not detected	1		ug/L	1	100-42-5	
Isopropylbenzene	Not detected	5		ug/L	1	98-82-8	
Bromoform	Not detected	1		ug/L	1	75-25-2	
1,1,2,2-Tetrachloroethane	Not detected	1		ug/L	1	79-34-5	
1,2,3-Trichloropropane	Not detected	1		ug/L	1	96-18-4	
n-Propylbenzene	3	1		ug/L	1	103-65-1	
Bromobenzene	Not detected	1		ug/L	1	108-86-1	
1,3,5-Trimethylbenzene	Not detected	1		ug/L	1	108-67-8	
tert-Butylbenzene	Not detected	1		ug/L	1	98-06-6	
1,2,4-Trimethylbenzene	5	1		ug/L	1	95-63-6	
sec-Butylbenzene	Not detected	1		ug/L	1	135-98-8	
p-Isopropyltoluene	Not detected	5		ug/L	1	99-87-6	
1,3-Dichlorobenzene	Not detected	1		ug/L	1	541-73-1	
1,4-Dichlorobenzene	Not detected	1		ug/L	1	106-46-7	
1,2-Dichlorobenzene	Not detected	1		ug/L	1	95-50-1	
1,2,3-Trimethylbenzene	2	1		ug/L	1	526-73-8	
n-Butylbenzene	Not detected	1		ug/L	1	104-51-8	
Hexachloroethane	Not detected	5		ug/L	1	67-72-1	
1,2-Dibromo-3-chloropropane	Not detected	5		ug/L	1	96-12-8	
1,2,4-Trichlorobenzene	Not detected	5		ug/L	1	120-82-1	
1,2,3-Trichlorobenzene	Not detected	5		ug/L	1	87-61-6	
Naphthalene	Not detected	5		ug/L	1	91-20-3	
2-Methylnaphthalene	Not detected	5		ug/L	1	91-57-6	

Merit Laboratories Login Checklist

Lab Set ID: S82318
Client: ARCADIS_NOVI (Arcadis US, Inc.)
Project: 30267726.00005 / RACER PNC
Submitted: 12/11/2025 15:50 Login User: PFD

Attention: Alexis Nickerson
Address: Arcadis US, Inc.
28550 Cabot Drive, Suite 500
Novi, MI 48377

Phone: 614-985-9163 FAX:
Email: Alexis.Nickerson@arcadis.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 4.9
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[X] No	[ ] N/A	Do water VOC, TOX, DO or Alkalinity bottles contain	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories, Inc.
2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # 1 OF 1

188872

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Alexis Nickerson
COMPANY: ARCADIS
ADDRESS: 28550 Cabot Dr #500
CITY: Novi | STATE: MI | ZIP CODE: 48377
PHONE NO.: 614-985-9163 | CELL NO.: | P.O. NO.:
E-MAIL ADDRESS: Tiffany.Linder@arcadis.com; Alexis.Nickerson@arcadis.com | QUOTE NO.:

INVOICE TO

CONTACT NAME: Accounts Payable ☐ SAME
COMPANY: ARCADIS
ADDRESS: 630 Plaza Dr #600
CITY: Highlands Ranch | STATE: CO | ZIP CODE: 80129
PHONE NO.: | E-MAIL ADDRESS: accounts payable.administration@arcadis.com

PROJECT NO./NAME: 30267726.00005 / Racer PNC
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Lottie Jay / Lottie Jay

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER

DELIVERABLES REQUIRED ☒ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☒ EDD ☐ OTHER

MATRIX CODE: W=WATER GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR WS=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES

Project Locations
☐ Detroit ☐ New York
☐ Other

Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	COLLECTION DATE	COLLECTION TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Full VOC list via method 8260
823801	12/11/25	1416	JS-MW-16_GW-121125	GW	3		3						X
.02	"	—	DUP-01_GW-121125	GW	3		3						X

LJ 12/11/25

RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
	Lottie Jay / Lottie Jay / ARCADIS ☒ Sampler	12/11/25	1430
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
		12/11/25	14:30
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
		12/11/25	15:30
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
		12/11/25	1552

RELINQUISHED BY: SIGNATURE/ORGANIZATION	DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION	DATE	TIME

SEAL NO. | SEAL INTACT YES ☐ NO ☐ | INITIALS
SEAL NO. | SEAL INTACT YES ☐ NO ☐ | INITIALS

☒ ICE (SOLID) ☐ BLUE ICE ☐ ICE (MELTED) ☐ NONE
TEMP. ON ARRIVAL: 4.9

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 02/25

Attachment 4

Mann-Kendall Analysis

Trend Analysis
RACER PNC - Joslyn
July 2026

STATISTICAL ANALYSIS METHODOLOGY

Arcadis conducted statistical analyses to assess whether constituent of concern (COC) concentrations have statistically significantly increasing or decreasing trends at 95 percent (%) confidence. The Mann-Kendall (MK) trend test is a non-parametric test that evaluates these trends based on ranked data. As such, it is relatively insensitive to outlier values and non-detect concentrations (values less than reporting limits) and does not require the data to fit a specific model. The test has the flexibility to be modified to account for multiple observations per time period, multiple sampling locations, and seasonality (USEPA 2006, 2009).

The MK trend test is performed by listing the COC concentrations in temporal order and computing the differences between a given measurement and earlier measurements (Gilbert 1987; USEPA 2009). The MK test statistic (sum of trend [S]) is the difference between the number of strictly positive differences and the number of strictly negative differences (the magnitude of change, or slope, is not considered). If S is positive, an increasing trend is indicated; if S is negative, a decreasing trend is indicated; and, if S is near zero, no trend is apparent. Trends with positive or negative S values are accepted as statistically significant for p-values less than or equal to 0.05 (95% confidence level). A minimum of four (preferably eight) sampling events per well is needed to run the MK trend test (USEPA, 2009). Where qualified values were used in computations, the concentrations were set equal to the reported value. Based on U.S. EPA guidance (USEPA 2009) for MK analyses, non-detect values are set to a single value less than that of any detections, so that any pair of tied values or any pair of non-detects is given a score of 0 in the calculation of S.

Statistical analyses of COC concentration trends were evaluated using the MK trend test for monitoring well and constituent pairs that met the following criteria:

1. At least 5 sampling results.
2. At least 50% of concentrations are detected measurements.

To further consider the stability of COC concentrations, MK analyses that were not statistically significant at 95% confidence were evaluated quantitatively using the coefficient of variation (CV) and qualitatively with visual inspection. The CV is a measure that can be used to assess relative stability of concentration trends. The CV is calculated as the standard deviation divided by the mean (average) concentration of a data set. In general, CV values greater than 1 indicate variability in concentrations over time while CV values less than 1 indicate that concentrations are stable.

TREND ANALYSES CONDUCTED

Sampling results from May 2021 to December 2025 for 1,2-dichloroethane (1,2-DCA), benzene, and ethylbenzene at a subset of monitoring wells were considered for screening. According to the criteria above, a total of 4 data sets qualified for statistical analysis.

Two of the qualifying data sets indicated statistically significantly decreasing trends, including ethylbenzene at JS-MW-06 and benzene at JS-MW-19.

1,2-DCA and benzene qualified for analysis at JS-MW-16, both of which indicated no statistically significant trend at the 95% confidence level. These two qualifying data sets with no statistically significant trend have CV values less than 1, indicating that concentrations are generally stable. Visual inspection generally confirms this conclusion, though the CV value is relatively high for 1,2-DCA at JS-MW-16 (0.82). This appears to be attributable to a short-term (three of the eleven sampling events) spike in concentrations between September 2022 and March 2023, though concentrations also appear to be potentially increasing over the last three sampling events (from non-detect in September 2024 to 7 ug/L in December 2025).

Results are presented in Table C-1, with corresponding charts in Figures C-1 through C-4. Figures include each constituent's corresponding screening levels (Groundwater Surface Water Interface [GSI], Residential Joslyn SSVIAC Base value, and Non-residential Joslyn SSVIAC <50k SOG value) for reference.

REFERENCES

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. John Wiley and Sons, Inc. New York.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data and RCRA Facilities Unified Guidance. Office of Resource Conservation and Recovery. March.

TABLE 4-1
Summary Statistics and Trend Results
RACER PNC (Joslyn)
Pontiac, Michigan
July, 2026

Well ID	Analyte	Date Range	Figure	FOD	Detected Results Summary [1]					Mann-Kendall Test [2]			
					Range	Mean	Median	SD	CV	Result[4]	MK Result Note	P-Value	S Value
JS-MW-06	Ethylbenzene	05/21 - 09/25	4-1	5 / 7	14 - 488	207	69	239	1.15	DWN	5a	0.003	-18
JS-MW-16	1,2-Dichloroethane	12/21 - 12/25	4-2	9 / 11	1 - 13	5.6	5	4.6	0.82	NST	--	0.468	-2
JS-MW-16	Benzene	12/21 - 12/25	4-3	10 / 11	2 - 9	4.5	3.5	2.5	0.56	NST	--	0.238	10
JS-MW-19	Benzene	12/21 - 09/25	4-4	6 / 10	3 - 18	8	4.5	6.7	0.84	DWN	--	0.004	-30

Abbreviations:

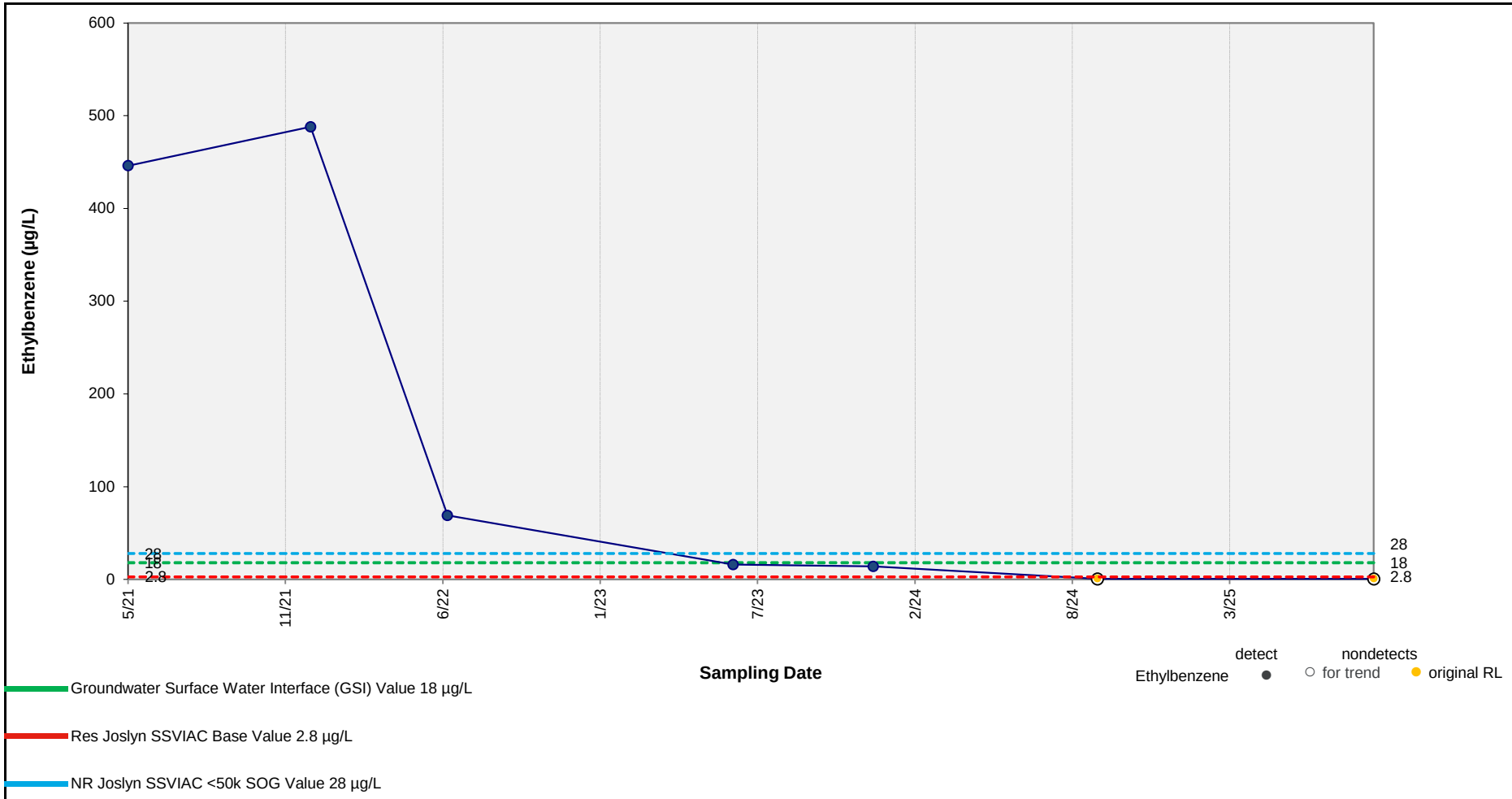
-- = not applicable
FOD = frequency of detection (# detects / # samples)
CV = coefficient of variation (SD / mean)
mean = arithmetic mean
MK = Mann-Kendall
SD = standard deviation
NST = no significant trend
DWN = downward trend
UP = upward trend

Notes:

1. All analytical results are in µg/L.
2. Trend results are presented when at least five samples and 50% detected values are available.
3. Non-detects were assigned a common value less than the minimum detected value, equal to half the minimum reporting limit (RL) in the dataset (USEPA, 2009). If half the minimum RL was greater than the minimum detected value, then half the minimum detect was assigned.
4. Statistically significant trend defined as having p-value ≤ 0.05, or 95% confidence.
5a. MK Trend results for datasets with fewer than 8 samples may not be reliable and should be treated with caution.

Reference:

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance. EPA/530/R-09/007, 2009.



Results of Mann-Kendall Test for Trend: **DECREASING TREND**

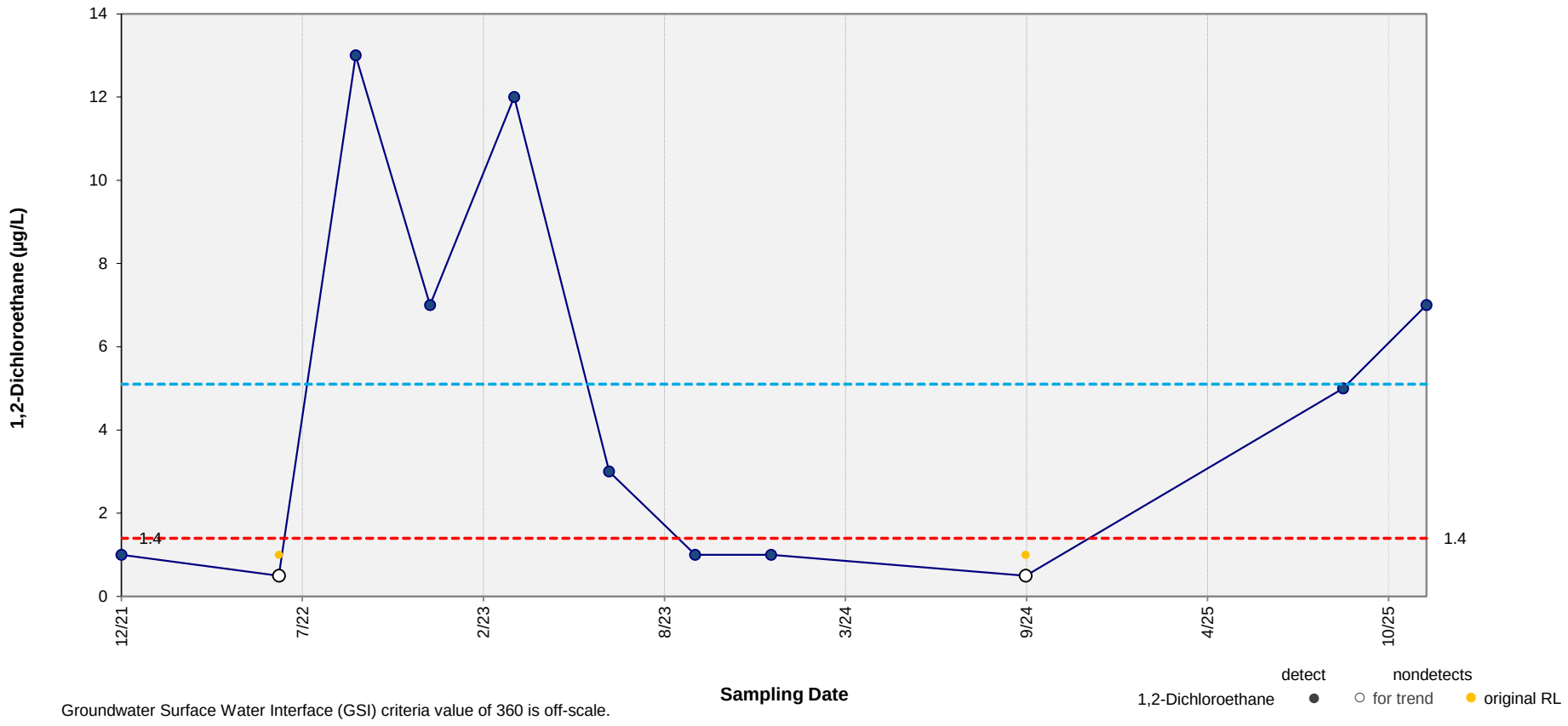
p value = 0.003 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

ARCADIS

Concentration vs. Time Plot – Ethylbenzene in Well JS-MW-06

RACER PNC (Joslyn)

Figure 4-1



Groundwater Surface Water Interface (GSI) criteria value of 360 is off-scale.

Res Joslyn SSVIAC Base Value 1.4 µg/L

NR Joslyn SSVIAC <50k SOG Value 5.1 µg/L

Results of Mann-Kendall Test for Trend: **No Significant Trend**

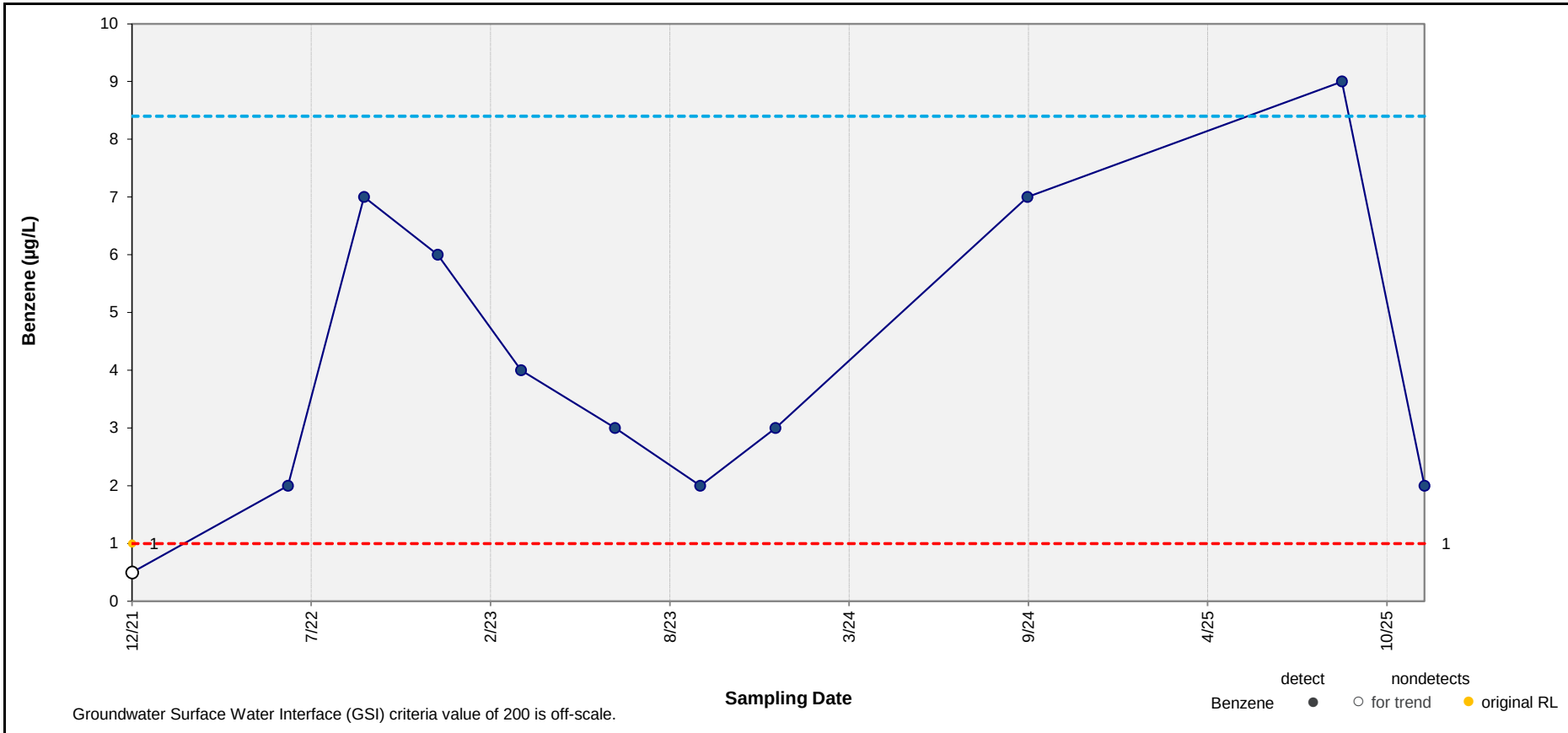
p value = 0.468 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

ARCADIS

Concentration vs. Time Plot – 1,2-Dichloroethane in Well JS-MW-16

RACER PNC (Joslyn)

Figure 4-2



Groundwater Surface Water Interface (GSI) criteria value of 200 is off-scale.

Res Joslyn SSVIAC Base Value 1 µg/L

NR Joslyn SSVIAC <50k SOG Value 8.4 µg/L

Results of Mann-Kendall Test for Trend: **No Significant Trend**

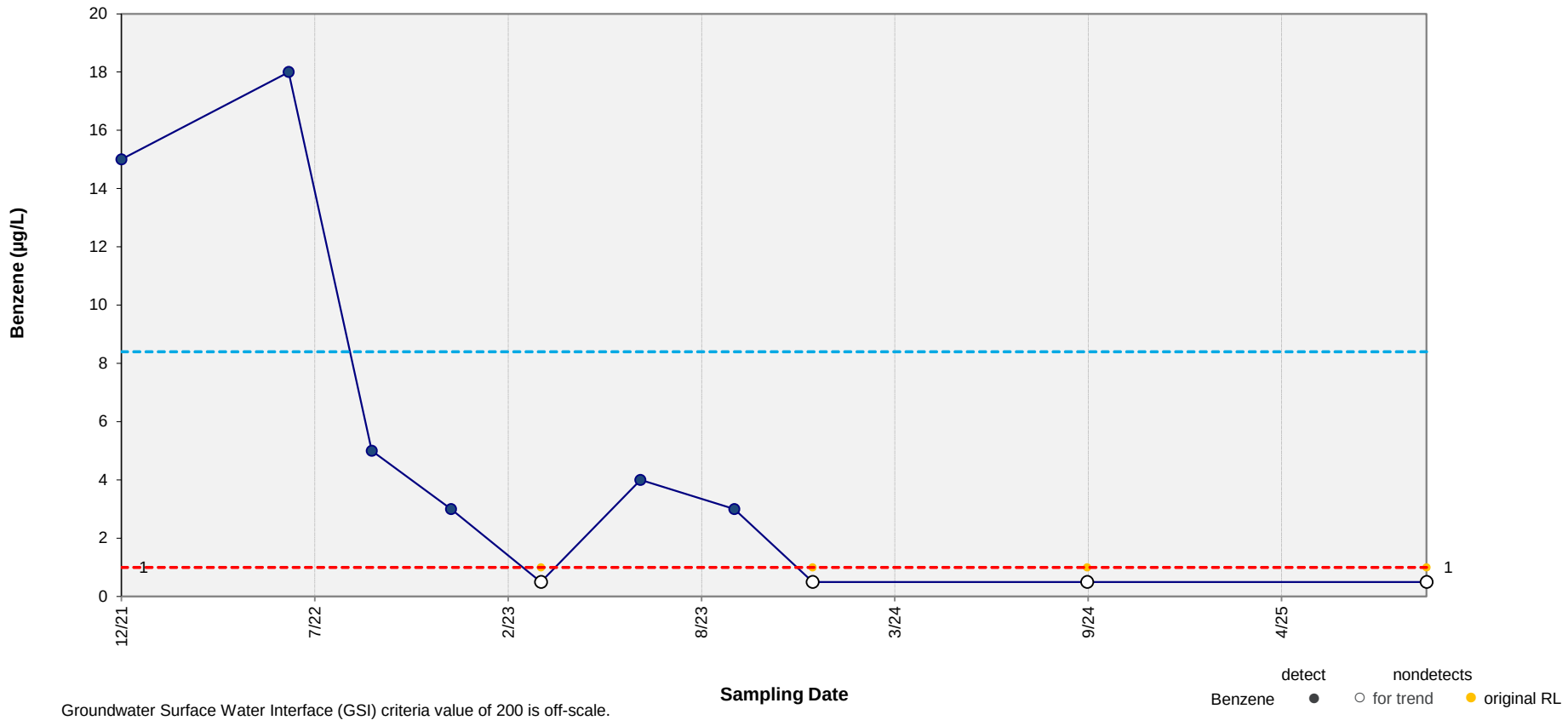
p value = 0.238 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

ARCADIS

Concentration vs. Time Plot – Benzene in Well JS-MW-16

RACER PNC (Joslyn)

Figure 4-3



Groundwater Surface Water Interface (GSI) criteria value of 200 is off-scale.

Res Joslyn SSVIAC Base Value 1 µg/L

NR Joslyn SSVIAC <50k SOG Value 8.4 µg/L

Results of Mann-Kendall Test for Trend: **DECREASING TREND**

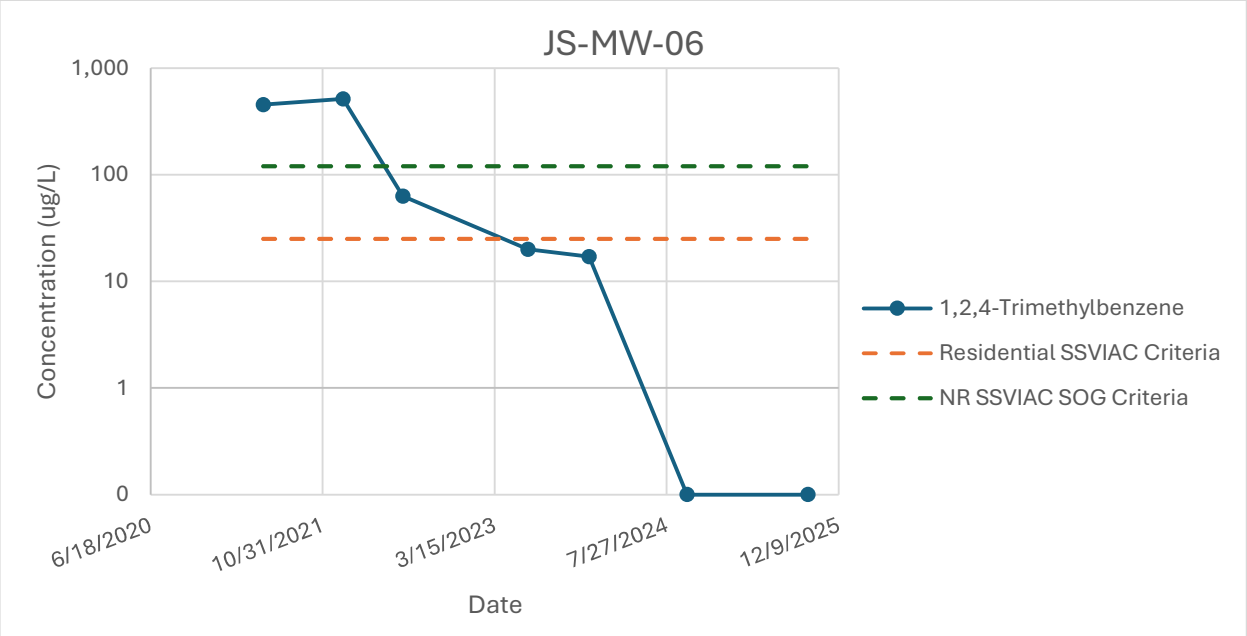
p value = 0.004 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

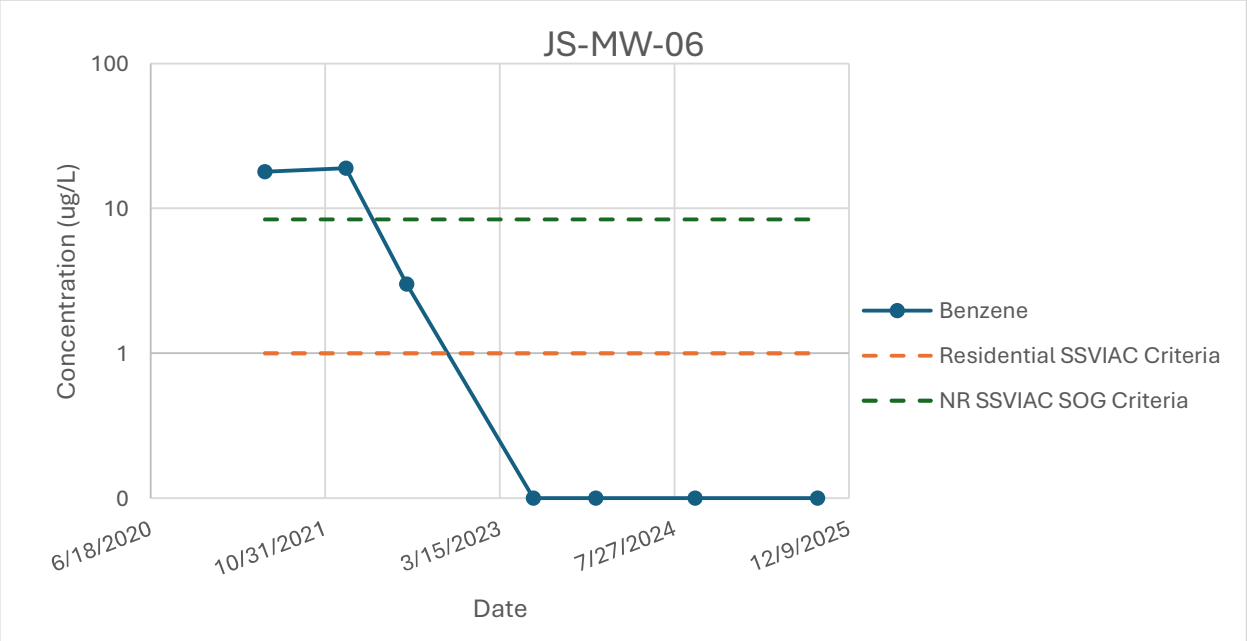
ARCADIS

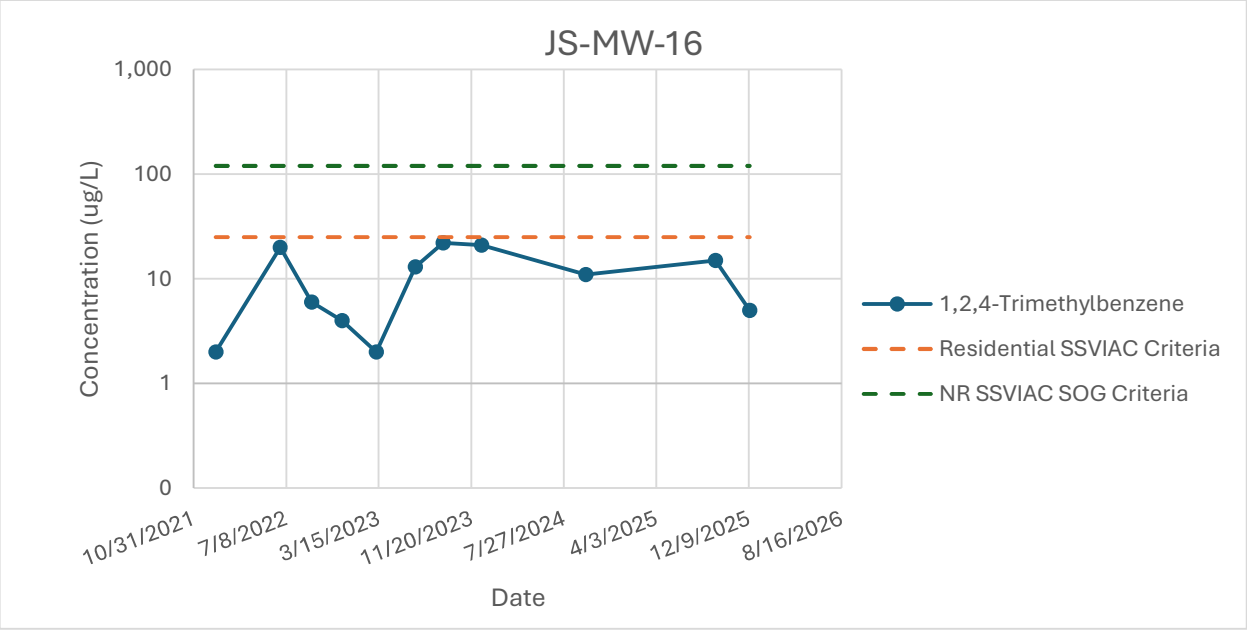
Concentration vs. Time Plot – Benzene in Well JS-MW-19

RACER PNC (Joslyn)

Figure 4-4


JS-MW-06
1,000
100
10
1
0
Concentration (ug/L)
6/18/2020
10/31/2021
3/15/2023
7/27/2024
12/9/2025
Date
1,2,4-Trimethylbenzene
Residential SSVIAC Criteria
NR SSVIAC SOG Criteria


JS-MW-06
100
10
1
0
Concentration (ug/L)
6/18/2020
10/31/2021
3/15/2023
7/27/2024
12/9/2025
Date
Benzene
Residential SSVIAC Criteria
NR SSVIAC SOG Criteria


JS-MW-16
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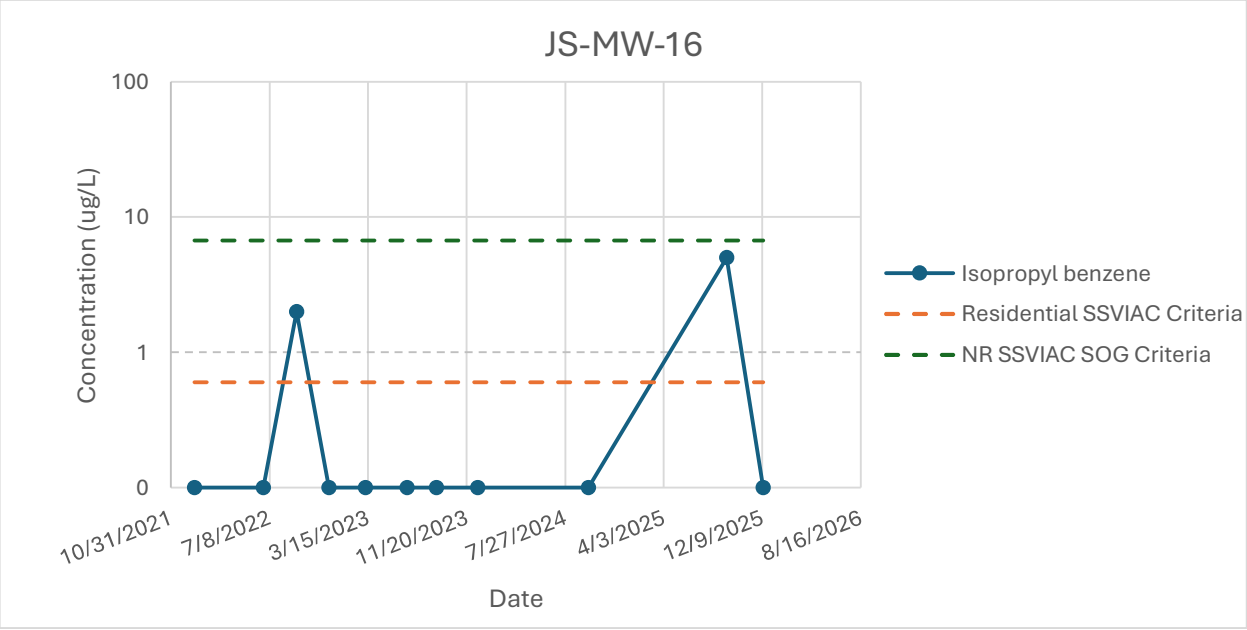
100
10
1
0
Concentration (ug/L)
10/31/2021
7/8/2022
3/15/2023
11/20/2023
7/27/2024
4/3/2025
12/9/2025
8/16/2026
Date
1,2,4-Trimethylbenzene
Residential SSVIAC Criteria
NR SSVIAC SOG Criteria


JS-MW-16
100
10
1
0
Concentration (ug/L)
10/31/2021
7/8/2022
3/15/2023
11/20/2023
7/27/2024
4/3/2025
12/9/2025
8/16/2026
Date
Isopropyl benzene
Residential SSVIAC Criteria
NR SSVIAC SOG Criteria

Attachment 5

Laboratory Standard Operating Procedures

ANALYTICAL METHODS

Section 9.0

Method: EPA Method TO-14A/TO-15 Volatile Organic Compounds (Standard/QUAD)			
Laboratory SOP #: 6	Revision #: 50	Effective Date: May 28, 2024	Methods Manual Summary

Description: This method involves full scan gas chromatograph/mass spectrometer (GC/MS) analysis of whole air samples collected in evacuated stainless steel canisters. Samples are analyzed for volatile organic compounds (VOCs) using EPA Method TO-14A/TO-15 protocols. An aliquot of up to 0.5 liters of air is withdrawn from the canister utilizing a volumetric loop or mass flow controller. This volume is loaded onto a hydrophobic multibed sorbent trap to remove water and carbon dioxide and to concentrate the vapor sample. The focused sample is then flash-heated to sweep adsorbed VOCs onto a secondary trap for further concentration and/or directly onto a GC/MS for separation and detection.

Eurofins Environment Testing Northern California, LLC maintains a suite of TO-14A/TO-15 methods, each optimized to efficiently meet the data objectives for a wide range of targeted concentration ranges. The methods, their reporting limits, and typical applications are summarized in the table below. This method summary describes TO-14A/TO-15 full scan (Standard or QUAD).

Eurofins Environment Testing Northern California, LLC Method	**Base Reporting Limits**	**Typical Application**
TO-14A/TO-15 Full Scan (5&20)	5 – 20 ppbv	Soil gas and ppmv range vapor matrices
TO-14A/TO-15 Full Scan (Standard or QUAD)	0.5 – 5.0 ppbv	Ambient air, soil gas, and ppbv level vapor matrices
TO-14A/TO-15 Full Scan (Low-level)	0.1 – 1.0 ppbv	Indoor and outdoor air
TO-14A/TO-15 SIM	0.01 – 0.5 ppbv	Indoor and outdoor air

Certain compounds are not included in Eurofins Environment Testing Northern California, LLC's standard target analyte list. These compounds are communicated at the time of client proposal request. Unless otherwise directed, Eurofins Environment Testing Northern California, LLC reports these non-routine compounds with partial validation. Validation may include a 3-point calibration with the lowest concentration defining the reporting limit, no second source verification analyzed, and no method detection limit study performed unless previous arrangements have been made. In addition, stability of the non-standard compound during sample storage is not validated. Full validation may be available upon request.

Eurofins Environment Testing Northern California, LLC takes no modifications of technical significance to Method TO-15 for the "QUAD" configurations. Since Eurofins Environment Testing Northern California, LLC applies TO-15 methodology to all Summa canisters regardless of whether TO-14A or TO-15 is specified by the project, the laboratory has

established modifications to method TO-14A as detailed in Table 1. Please note that Methods TO-14A and TO-15 were validated for specially treated canisters. As such, the use of Tedlar bags for sample collection is outside the scope of the method and not recommended for ambient or indoor air samples. It is the responsibility of the data user to determine the usability of TO-14A and TO-15 results generated from Tedlar bags.

Table 1. Summary of TO-14A Method Modifications

Requirement	TO-14A	Laboratory Modifications
Sample Drying System	Nafion Drier	Multibed hydrophobic sorbent.
Blank acceptance criteria	≤ 0.2 ppbv	≤ RL
BFB ion abundance criteria	Ion abundance criteria listed in Table 4 of TO-14A	Follow abundance criteria listed in TO-15.
BFB absolute abundance criteria	Within 10% when comparing to the previous daily BFB	CCV internal standard area counts are compared to ICAL; corrective action when recovery is less than 60%.
Initial Calibration	≤ 30% RSD for listed 39 VOCs	Follow TO-15 requirements of ≤ 30% RSD with 2 of Laboratory's 62 standard compounds allowed out to ≤ 40% RSD

The standard target analyte list, reporting limit (RL) also referred to as Limit of Quantitation, QC criteria, and QC summary can be found in Tables 2 through 6.

Table 2 is the standard list of accredited compounds (except where noted), reporting limits and QC acceptance criteria. Each project may be customized as needed. Additional compounds and different reporting limits may be obtainable and/or achieved upon request.

Table 2. Method TO-14A/TO-15 Analyte List (QUAD)

Analyte	RL/LOQ (ppbv)	QC Acceptance Criteria			
		ICAL (%RSD)	CCV (%R)	ICV/LCS (%R)	Precision Limits (Max. RPD)
1,1,2,2-Tetrachloroethane	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,1,2-Trichloroethane	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,1-Dichloroethane	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,1-Dichloroethene	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,2,4-Trichlorobenzene	2.0	≤ 30%	70 – 130	70 – 130	± 25
1,2,4-Trimethylbenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,2-Dibromoethane (EDB)	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,2-Dichlorobenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,2-Dichloroethane	0.5	≤ 30%	70 – 130	70 – 130	± 25

Analyte	RL/LOQ (ppbv)	QC Acceptance Criteria			
		ICAL (%RSD)	CCV (%R)	ICV/LCS (%R)	Precision Limits (Max. RPD)
1,2-Dichloropropane	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,3,5-Trimethylbenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,3-Dichlorobenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,4-Dichlorobenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Benzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Bromomethane	1.0	≤ 30%	70 – 130	70 – 130	± 25
Carbon Tetrachloride	0.5	≤ 30%	70 – 130	70 – 130	± 25
Chlorobenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Chloroethane	2.0	≤ 30%	70 – 130	70 – 130	± 25
Chloroform	0.5	≤ 30%	70 – 130	70 – 130	± 25
Chloromethane	5.0	≤ 30%	70 – 130	70 – 130	± 25
Chlorotoluene (Benzyl Chloride)	0.5	≤ 30%	70 – 130	70 – 130	± 25
cis-1,2-Dichloroethene	0.5	≤ 30%	70 – 130	70 – 130	± 25
cis-1,3-Dichloropropene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Dichloromethane (Methylene Chloride)	1.0	≤ 30%	70 – 130	70 – 130	± 25
Ethylbenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Freon 11 (Trichlorofluoromethane)	0.5	≤ 30%	70 – 130	70 – 130	± 25
Freon 113 (Trichlorotrifluoroethane)	0.5	≤ 30%	70 – 130	70 – 130	± 25
Freon 114	0.5	≤ 30%	70 – 130	70 – 130	± 25
Freon 12 (Dichlorodifluoromethane)	0.5	≤ 30%	70 – 130	70 – 130	± 25
Hexachlorobutadiene	2.0	≤ 30%	70 – 130	70 – 130	± 25
m,p-Xylene	1.0	≤ 30%	70 – 130	70 – 130	± 25
Methyl Chloroform (1,1,1-Trichloroethane)	0.5	≤ 30%	70 – 130	70 – 130	± 25
o-Xylene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Styrene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Tetrachloroethene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Toluene	1.0	≤ 30%	70 – 130	70 – 130	± 25
trans-1,3-Dichloropropene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Trichloroethene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Vinyl Chloride	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,3-Butadiene	0.5	≤ 30%	70 – 130	70 – 130	± 25
1,4-Dioxane	1.0	≤ 30%	70 – 130	70 – 130	± 25

Analyte	RL/LOQ (ppbv)	QC Acceptance Criteria			
		ICAL (%RSD)	CCV (%R)	ICV/LCS (%R)	Precision Limits (Max. RPD)
2-Butanone (Methyl Ethyl Ketone)	2.0	≤ 30%	70 – 130	70 – 130	± 25
2-Hexanone	2.0	≤ 30%	70 – 130	70 – 130	± 25
4-Ethyltoluene	0.5	≤ 30%	70 – 130	70 – 130	± 25
4-Methyl-2-Pentanone (MIBK)	0.5	≤ 30%	70 – 130	70 – 130	± 25
Acetone	5.0	≤ 30%	70 – 130	70 – 130	± 25
Bromodichloromethane	0.5	≤ 30%	70 – 130	70 – 130	± 25
Bromoform	0.5	≤ 30%	70 – 130	70 – 130	± 25
Carbon Disulfide	2.0	≤ 30%	70 – 130	70 – 130	± 25
Cyclohexane	0.5	≤ 30%	70 – 130	70 – 130	± 25
Dibromochloromethane	0.5	≤ 30%	70 – 130	70 – 130	± 25
Ethanol	5.0	≤ 30%	70 – 130	70 – 130	± 25
Heptane	0.5	≤ 30%	70 – 130	70 – 130	± 25
Hexane	0.5	≤ 30%	70 – 130	70 – 130	± 25
Isopropanol	2.0	≤ 30%	70 – 130	70 – 130	± 25
Methyl t-Butyl Ether (MTBE)	2.0	≤ 30%	70 – 130	70 – 130	± 25
Tetrahydrofuran	0.5	≤ 30%	70 – 130	70 – 130	± 25
trans-1,2-Dichloroethene	0.5	≤ 30%	70 – 130	70 – 130	± 25
2,2,4-Trimethylpentane	0.5	≤ 30%	70 – 130	70 – 130	± 25
Cumene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Propylbenzene	0.5	≤ 30%	70 – 130	70 – 130	± 25
3-Chloropropene	0.5	≤ 30%	70 – 130	70 – 130	± 25
Naphthalene*	1.0	≤40%	60 – 140	60 – 140	± 25
TPH (Gasoline) **	50	1-Point Calibration	N/A	ICV only; 60 – 140	± 25
NMOC (Hexane/Heptane)**	10	1-Point Calibration	N/A	NA	± 25

*Due to its low vapor pressure, Naphthalene may exceed TO-15 performance requirements. The wider QC limits reflect typical performance. Although Naphthalene is not on Eurofins Environment Testing Northern California, LLC's "standard" TO-15 list, it is commonly requested and included in Table 2.

**TPH and NMOC are not on Eurofins Environment Testing Northern California, LLC's "standard" TO-15 list, but are included in Table 2 due to common requests. These are semi-quantitative non-accredited parameters.

Table 3 is the list of non-standard NELAP accredited Method TO-15 compounds that may be requested.

Table 3. Method TO-15 Additional Analyte List (QUAD)

Analyte	RL/LOQ (ppbv)	QA Acceptance Criteria			
		ICAL (%RSD)	CCV (%R)	ICV/LCS (%R)	Precision Limits (Max. RPD)
1,1,1,2-Tetrachloroethane	0.5	≤30%	70 – 130	70 – 130	± 25
1,2,3-Trichloropropane	0.5	≤30%	70 – 130	70 – 130	± 25
1,2-Dibromo-3-chloropropane	2.0	≤30%	70 – 130	70 – 130	± 25
1,3-Dichloropropane	0.5	≤30%	70 – 130	70 – 130	± 25
2-Chlorotoluene	2.0	≤30%	70 – 130	70 – 130	± 25
Acrylonitrile	0.5	≤30%	70 – 130	70 – 130	± 25
alpha-methyl-styrene	2.0	≤30%	70 – 130	70 – 130	± 25
4-Isopropyltoluene (p-Cymene)	2.0	≤30%	70 – 130	70 – 130	± 25
Bromobenzene	2.0	≤30%	70 – 130	70 – 130	± 25
Butane	2.0	≤30%	70 – 130	70 – 130	± 25
Butyl Benzene	0.5	≤30%	70 – 130	70 – 130	± 25
Dibromomethane	0.5	≤30%	70 – 130	70 – 130	± 25
Ethyl Acetate	2.0	≤30%	70 – 130	70 – 130	± 25
Freon 21 (Dichlorofluoromethane)	2.0	≤30%	70 – 130	70 – 130	± 25
Freon 22 (Chlorodifluoromethane)	2.0	≤30%	70 – 130	70 – 130	± 25
Isobutane	2.0	≤30%	70 – 130	70 – 130	± 25
Isopentane	2.0	≤30%	70 – 130	70 – 130	± 25
Methyl Methacrylate	2.0	≤30%	70 – 130	70 – 130	± 25
Methylcyclohexane	2.0	≤30%	70 – 130	70 – 130	± 25
Nonane	2.0	≤30%	70 – 130	70 – 130	± 25
n-Pentane	2.0	≤30%	70 – 130	70 – 130	± 25
Propylene	2.0	≤30%	70 – 130	70 – 130	± 25
Octane	2.0	≤30%	70 – 130	70 – 130	± 25
sec-Butylbenzene	0.5	≤30%	70 – 130	70 – 130	± 25
tert-Butyl Alcohol	2.0	≤30%	70 – 130	70 – 130	± 25
tert-Butyl Benzene	2.0	≤30%	70 – 130	70 – 130	± 25
Vinyl Acetate	2.0	≤30%	70 – 130	70 – 130	± 25
Vinyl Bromide	0.5	≤30%	70 – 130	70 – 130	± 25

Table 4. Internal Standards

Analyte	Accuracy (% R)
Bromochloromethane	60 – 140
1,4-Difluorobenzene	60 – 140
Chlorobenzene-d_5	60 – 140

Table 5. Surrogates

Analyte	Accuracy (% R)
1,2-Dichloroethane-d_4	70 – 130
Toluene-d_8	70 – 130
4-Bromofluorobenzene	70 – 130

Table 6. Summary of Calibration and QC Procedures for Methods TO-14A/TO-15

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Tuning Criteria	Every 24 hours	TO-15 ion abundance criteria	Correct problem then repeat tune.
Minimum 5-Point Initial Calibration (ICAL)	Prior to sample analysis	% RSD ≤ 30 with 2 compounds allowed out to ≤ 40% RSD	Correct problem then repeat Initial Calibration curve.
Initial Calibration Verification and Laboratory Control Sample (ICV and LCS)	After each Initial Calibration curve, and daily prior to sample analysis	Recoveries for 85% of "Standard" compounds must be 70–130%. No recovery may be < 50%. ICV evaluated on a full list basis at the time of calibration. If specified by the project, in-house generated control limits may be used.	Check the system and reanalyze the standard. Re-prepare the standard if necessary to determine the source of error. Re-calibrate the instrument if the primary standard is found to be in error.
Continuing Calibration Verification (CCV) for Standard compounds	At the start of each analytical clock after the tune check	70–130%	Compounds exceeding this criterion and associated data will be flagged and narrated with the exception of high bias associated with non-detects. If more than two compounds from the standard list recover outside of 70–130% or > 10% of VOCs if short list is used (20 compounds or less), corrective action will be taken. If any compound exceeds 60–140%, samples are not analyzed unless data meets project needs. Check the system and reanalyze the standard. Re-prepare the standard if necessary. Re-calibrate the instrument if the criteria cannot be met.
Laboratory Blank	After analysis of standards and prior to sample analysis, or when contamination is present.	Results less than the laboratory reporting limit	Inspect the system and re-analyze the blank. "B"-flag data for common contaminants.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Internal Standard (IS)	As each standard, blank, and sample is being loaded	Retention time (RT) for blanks and samples must be within ±0.33 min of the RT in the CCV and within ±40% of the area counts of the daily CCV internal standards.	**For blanks:** Inspect the system and reanalyze the blank. **For samples:** Re-analyze the sample. If the ISs are within limits in the re-analysis, report the second analysis. If ISs are out-of-limits a second time, dilute the sample until ISs are within acceptance limits and narrate.
Surrogates	As each standard, blank, and sample is being loaded	70–130% If specified by the project, in-house generated control limits may be used.	**For blanks:** Inspect the system and reanalyze the blank. **For samples:** Re-analyze the sample unless obvious matrix interference is documented. If the %Rs are within limits in the re-analysis, report the second analysis. If %Rs are out-of-limits a second time, report data from first analysis and narrate.
Laboratory Duplicates – Laboratory Control Sample Duplicates (LCSD)	One per analytical batch	RPD ≤25%	Narrate exceedances. If more than 5% of compound list is outside criteria or if compound has >40%RPD, investigate the cause and perform maintenance as required. If instrument maintenance is required, calibrate as needed.

STANDARD OPERATING PROCEDURE

VOLATILE ORGANIC COMPOUNDS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY
METHOD SW-846 8260C/ EPA 624.1

APPROVALS:

Barbara Ball

03/22/2024

QA Officer Date

Mayra Mushaly

03/22/2024

Technical Director Date

Number	Description of Change	Date
001-011	Previous revisions not documented	
0012	Updated to comply with DoD QSM and ISO 17025 standards.	6/9/11
013	Updated to method 8260C	9/4/13
014	Updated to comply with DoD QSM 5.0 standards.	04/01/16
015	Updated to comply with DoD QSM 5.1 standards.	01/17/18
016	NY NELAC Audit Finding	03/13/19
017	DOD Audit Corrective Action	09/29/2020
018	2020 Internal Audit revisions	02/16/2021
019	NY NELAC Audit Finding	05/25/2022
020	Emergency SOP Amendment Form	03/08/2023
021	2023 Internal Audit revisions	03/22/2024
022		

1.0 SCOPE AND APPLICATION

This SOP is used to determine volatile organic compounds (VOC) in a variety of matrices, regardless of water content, including various air sampling trapping media, ground and surface water, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. See Table 1 for a list of compounds (along with their characteristic ions) that have been evaluated.

There are various techniques by which these compounds may be introduced into the GC/MS system. Purge-and-trap, by SW-846 Methods 5030C (aqueous samples) and 5035A (solid, waste, and oil samples), are the most commonly used technique for volatile organic analytes. SW-846 Method 5000 provides general information on the selection of other introduction methods.

The practical quantitation limit (PQL) for an individual compound is instrument dependent and also dependent on the choice of the sample preparation/introduction method. Using standard quadrapole instrumentation and the purge-and-trap technique, limits should be approximately 50 µg/kg (wet weight) for solid samples and 1 µg/L for ground water. When lower reportable detection limits (RDLs) are required, the mass spectrometer (MS) can be set to selective ion monitoring (SIM) to achieve limits approximately 20 times lower then obtainable using the full scan method. Regardless of the sample matrix, PQLs will be proportionately higher for sample extracts and samples that require dilution or when a reduced sample size is used to avoid saturation of the detector.

Method Detection Limits (MDL) and Practical Quantitation Limits (PQL) are available in Merit's LIMs system.

This SOP is restricted to use by, or under the supervision of, analysts experienced in the use of gas chromatograph/mass spectrometers, and skilled in the interpretation of mass spectra and their use as a quantitative tool.

This SOP is not for use with samples that come into the lab for OHIO VAP work.

2.0 SUMMARY OF THE METHOD

VOC are introduced into the gas chromatograph by the purge-and-trap method or by other methods. The analytes are introduced directly to a wide-bore capillary column. The column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer interfaced to the gas chromatograph.

Analytes eluted from the capillary column are introduced into the mass spectrometer via a jet separator or a direct connection. Identification of target analytes is accomplished by comparing their mass spectra

with the electron impact spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard using a five point (or more) calibration curve.

The method includes specific calibration and quality control steps that supersede the general requirements provided in SW-846 Method 8000.

3.0 INTERFERENCES

Major contaminant sources are volatile materials in the laboratory and impurities in the inert purging gas and in the sorbent trap. The use of non-polytetrafluoroethylene (PTFE) thread sealants, plastic tubing, or flow controllers with rubber components should be avoided, since such materials out-gas organic compounds will be concentrated in the trap during the purge operation.

Cross-contamination may occur when any sample is analyzed immediately after a sample containing high concentrations of volatile organic compounds. After the analysis of a sample containing high concentrations of volatile organic compounds, one or more blanks should be analyzed to allow the system to be cleaned as well as to demonstrate the ultimate absence of cross-contamination. Alternatively, if the sample immediately following the high concentration sample does not contain the volatile organic compounds present in the high level sample, freedom from contamination has been established.

4.0 APPARATUS AND MATERIALS

Gas chromatograph/mass spectrometer system

- Gas chromatograph - An analytical system complete with a temperature programmable gas chromatograph suitable for splitless injection and all required accessories, including syringes, analytical columns, and gases. The capillary column should be directly coupled to the source.
- 20 m × 0.18 mm ID capillary column coated with DB-624 (J&W Scientific), Rt_x-502.2 (RESTEK), or VOCOL (Supelco), 1-µm film thickness, or equivalent.
- Mass spectrometer capable of scanning from 35 to 260 amu every 2 sec or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for 4-bromofluorobenzene (BFB) which meets the criteria in Table 4.
- GC/MS interface - The capillary column is interfaced through a direct connection to the GC/MS system.

- Data system - A computer system is interfaced to the mass spectrometer. Hewlett-Packard Chemstation software (with environmental data analysis) is used to acquire and process GC/MS data.

Purge-and-trap device.

Microsyringes - 10 to 500-µL.

Balance - Analytical, capable of weighing 0.001 g, and top-loading, capable of weighing 0.1 g.

Glass bottles - 40-mL, with PTFE-lined screw-caps.

pH paper.

5.0 REAGENTS

Reagent grade organic chemicals shall be used in all tests. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without introducing adverse interferences.

Organic-free reagent water - All references to water in this method refer to organic-free reagent water.

Stock standard solutions.

- Certified stock standard solutions are purchased when available for the bulk of desired analytes. They are typically available at concentrations of 1000 to 2000 mg/L.
- Supplemental compounds added to calibration mixes are generally prepared gravimetrically from neat standard references (in order to create a high-concentration stock solution).
- Stock standard solutions are stored in bottles with PTFE-lined screw-caps. They are refrigerated and protected from light, as recommended by the standard manufacturer.
- Stock standard solutions are replaced prior to expiration, or sooner if comparison with quality control check samples indicate a problem.

Internal standard solutions - The internal standards used are pentafluorobenzene, 1,4-difluorobenzene, chlorobenzene-d_5, and 1,4-dichlorobenzene-d_4 (see Table 2). Internal standards are used at a working concentration of 50 mg/L and are added to samples, spikes, blanks, and calibration standards at a uniform concentration of 50 µg/L (i.e. 10µL per 5000µL purge volume). For SIM (selective ion monitoring) analysis, internal standards of 1-4-Dioxane-d8, 1,2-Dibromoethane-D4, and 1,2-Dibromo-3-chloropropane-C3 is used, but with concentrations at 50 ppb for 1,4-Dioxane and 1,2-Dibromoethane-D4, and 1,2-Dibromo-3-chloropropane-C3 for 0.4 ppb (µg/L).

Calibration standards - A minimum of five calibration standards are prepared at different concentrations. The lowest calibration standard corresponds to a sample concentration at or below the standard reporting limit. The remaining standards should represent the working range of the GC/MS system. Each standard should contain each analyte for quantitation by this method. For DoD projects, each standard shall contain all target compounds.

Surrogate standards - The surrogates used are toluene-d_8, 4-bromofluorobenzene, and 1,2-dichloroethane-d_4. Surrogate standards are used at a working concentration of 50 mg/L and are added to samples, spikes, blanks, and calibration standards at a uniform concentration of 50 µg/L, or less. For SIM (selective ion monitoring) analysis, surrogate standards are the same, but with concentrations at 0.4 ppb (µg/L).

Matrix spike (MS), matrix spike duplicate (MSD) and laboratory control standards (LCS) - Matrix spiking solutions are prepared using the same standards as those used for the calibration. For DoD projects, matrix spiking solutions shall contain all target compounds.

- Matrix spiking mixes for individual analytes are created at 100 mg/L and spiked into samples at 50 µg/L (*i.e.* 2.50µL per 5000µL purge volume).
- For SIM (selective ion monitoring) analysis, compounds of interest are spiked at concentrations of 0.1 ppb (µg/L).
- For 1-Dioxane, compounds of interest are spiked at concentrations of 50 ppb (µg/L).

Methanol, CH_3OH - Pesticide quality or equivalent, demonstrated to be free of analytes. Store apart from other solvents.

6.0 SAMPLE HANDLING AND PRESERVATION

Unanalyzed samples are refrigerated at 4 ± 2 degrees Celsius in sealed vials or containers.

Aqueous samples are preserved to a pH <2with HCl and/or $Na_2S_2O_3$ (unless unpreserved requested) and collected in a 40 ml. Preserved samples must be analyzed within 14 days from sample collection; unpreserved samples must be analyzed within 7 days from sample collection.

Soil samples collected Encore™ Samplers must be preserved within 48 hours and analyzed within 14 days. Soil samples collected in glass jars shall be kept refrigerated and analyzed within 14 days from sample collection. For additional information on sample collection, handling and preservation for soil samples see SOP #ORL-005.

7.0 PROCEDURE

Sample introduction.

- Direct injection - This method of introduction is used only rarely, generally when the compounds of interest exhibit poor purging efficiency. Quantitation in this case, if required, is generally subject to external standard calibration procedures (*cf*. Method 8000).
- Purge-and-trap - This is generally used for sample introduction for both soil and water samples. All samples, standards, spikes, and blanks are introduced into the GC/MS system in an identical manner (see Merit SOP# ORL-005).

GC/MS operating conditions - see Table 3 for routine operating conditions for VOC analysis.

- For SIM, the MS is put into the SIM mode. Based on compounds of interest, the time windows are set within the run (i.e. for internal standards, surrogate standards, compounds). For each time window, corresponding to a compound, a minimum of 3 ions are chosen for qualitative analysis. One ion (primary ion), generally the most abundant ion is used for quantitative analysis.

Initial calibration.

- Each GC/MS system must be hardware-tuned to meet the criteria in Table 4 for 4-bromofluorobenzene. Analysis does not begin until these criteria are met.
    - In the absence of any other manipulations, evaluate the mass spectrum of the peak apex or the scan immediately preceding or following from the total ion chromatogram for the BFB peak. This is the default approach used.
    - If the above evaluation is adversely affected by ion peak asymmetry, average the three highest intensity scans of the peak or average the mass spectrum ranging from the 10% initial peak intensity to the tailing 10% peak intensity level from the total ion chromatogram for the BFB peak.
    - If the above evaluation is adversely affected by background contamination, perform a background subtraction with a spectrum within 20 scans of the BFB peak which does not represent a target compound. Use of this procedure may be indicative of failing MS performance. The MS source should be cleaned and re-tuned.
    - The BFB mass intensity criteria in Table 4 are used as tuning acceptance criteria.

- All subsequent standards, samples, MS/MSDs, and blanks associated with a BFB analysis must use the identical mass spectrometer instrument conditions, Exception: for SIM, tune is run using full scan acquisition and subsequent samples are acquired using SIM.

♦ Purge and analyze each calibration standard (containing internal standards) and tabulate the area of the primary characteristic ion against concentration for each target analyte (as indicated in Table 1). A set of at least five calibration standards is necessary. The purge volume must be the same for all standards and sample extracts. Figure 1 shows a chromatogram of a midpoint calibration standard.

♦ Calculate response factors (*RF*s) for each target analyte relative to one of the internal standards as follows: $RF = A_s C_i / A_i C_s$. Here, A_s and A_i are the areas of the standard compound and corresponding internal standard, respectively. Likewise, C_s and C_i are the respective concentrations (in any consistent set of units) of the standard compound and corresponding internal standard.

♦ Response Factor Criteria

- It is recommended that a minimum response factor for the most common target analytes as noted in Table 2b, be demonstrated for each individual calibration level as a means to ensure that these compounds are behaving as expected. In addition, meeting the minimum response factor criteria for the lowest calibration level is important in demonstrating the desired sensitivity. Due to the large number of compounds that may be analyzed, some compounds will fail to meet this criteria. In particular, poor performers such as ketones and 1,2-dibromo-3-chloropropane are likely to fail this criteria but have been demonstrated to perform adequately overall.

- If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins. Possible problems include standard mixture degradation, contamination in the purge-and-trap system, excessively high or low purge flow rates, and active sites in the column or chromatographic system. Replacing the calibration standards, clipping and/or replacing the column will likely solve this problem.

♦ Evaluation of retention times - The relative retention time (RRT) of each target analyte in each calibration standard should agree within 0.06 RRT units. This is accomplished by setting the retention time extraction windows in the Chemstation software.

- Linearity of target analytes - If the %RSD of any target analytes is 20% or less, then the relative response factor may be assumed to be constant over the calibration range, and the average relative response factor may be used for quantitation.
    - Refer to SW-846 Method 8000 if a least-squares regression is used to determine a linear or quadratic fit to the calibration data. Quadratic polynomials are generally fit through the origin in order to prevent the symptomatic aphysical prediction of high concentrations at very low responses. The coefficient of determination for any regression fit should be ≥0.99. In addition, 6 calibration data points are required for a calibration fit with 3 free parameters, while 5 are required for a calibration fit with 1 or 2 free parameters.
    - When the RSD exceeds 20%, the plotting and visual inspection of a calibration curve can be a useful diagnostic tool. The inspection may indicate analytical problems, including errors in standard preparation, the presence of active sites in the chromatographic system, analytes that exhibit poor chromatographic behavior, *etc*.
    - The method of linear regression analysis has the potential for a significant bias to the lower portion of a calibration curve, while the relative percent difference and the quadratic methods of calibration do not have this potential bias. When calculating the calibration curves using the linear regression model, a minimum quantitation check on the viability of the lowest calibration point should be performed by re-fitting the response from the low concentration calibration standard back into the curve. The recalculated concentration of the low calibration point should be within 30% of the standard's true concentration. Other recovery criteria may be applicable depending on the project's data quality objectives. For analytes which do not meet the minimum quantitation calibration re-fitting criteria reporting those analytes as estimated when the concentration is at or near the lowest calibration point may be appropriate.
    - The initial calibration curve should be verified immediately after performing the standard analyses using a second source standard at a concentration near the midpoint of the calibration range. The acceptance limits are 70-130% or project specific. Analytes that fail this criteria are considered estimated values.
    - The quality of the calibration fit for any particular compound is communicated to the data user via the Quality Control report for a given batch of samples. The calibration summary report includes: the concentration and RF for each standard in the calibration curve, the type of calibration fit, the calibration fit parameters (*i.e*. average RF or

regression coefficients), and the appropriate calibration quality metric (*i.e*. %RSD or COD).

- GC/MS calibration verification - Calibration verification consists of three steps that are performed at the beginning of each 12-hour analytical shift.
- Prior to the analysis of samples or calibration standards, purge the BFB standard into the GC/MS system. The resultant mass spectrum for BFB must meet the criteria given in Table 4 before sample analysis begins. These must be *injected* within 12 hours of the injection time for the BFB.
- The initial calibration for each compound of interest should be verified once every 12 hours prior to sample analysis, using the introduction technique and conditions used for samples. This is accomplished by analyzing a calibration standard at a concentration near the midpoint concentration for the calibration range of the GC/MS (50 µg/L; this represents 2.50 µL of the 100 mg/L calibration standard solution in a 5mL purge volume). A concentration of 0.1µg/L is analyzed for SIM procedures. The results from the calibration standard analysis must meet the verification acceptance criteria provided below. In addition the internal standards should be within 10s of those in the midpoint calibration standard and the responses should be 50-200% of those in the midpoint calibration standard.
- A method blank is run every 20 samples to ensure that the total system (preparation glassware, introduction device, transfer lines, and the GC/MS system itself) is free of contaminants. A method blank/wash sample is also run after calibration check/spike samples and prior to analytical samples in order to eliminate carryover contamination from the purge-and-trap system.
- Calibration Verification
  - A calibration verification must be made during every 12-hour analytical shift.
  - Each of the most common target analytes in the calibration verification standard should meet the minimum response factors as noted in Table 2b. This is the same check that is applied during the initial calibration and exceptions are noted above.
  - If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins.
  - All target compounds of interest must be evaluated using a 20% variability criterion. If the percent drift for a compound is less than or equal to 20%, then the initial calibration for that compound is assumed to be valid. Due to the large numbers of compounds that may be analyzed by this method, some compounds will fail to meet the criteria. If the criterion is not met for more than 20% of the compounds included in the initial

calibration, then corrective action must be taken prior to the analysis of samples. In cases where compounds fail, they may still be reported as non-detects if it can be demonstrated that there was adequate sensitivity to detect the compound at the applicable quantitation limit. For situations when a failed compound is present, the concentration is an estimated value. Drift is defined as the normalized deviation of the measured from the spike value of a target component: $\%D = \left|C - C_{spike}\right| / C_{spike}$.

- Problems similar to those listed under initial calibration could affect the calibration verification. If the problem cannot be corrected by other measures, a new initial calibration must be generated. The calibration verification criteria must be met before sample analysis begins.

GC/MS analysis of samples.

- Samples are screened at a diluted state via GC/MS whenever possible prior to analysis within a 12-hour QC batch. This can identify potentially low surrogate recoveries, high target compound concentrations, non-target matrix interferences. This will minimize contamination of the GC/MS system from unexpectedly high concentrations of organic compounds.
- Samples are introduced into the GC/MS system by loading the 40ml zero headspace vial onto the autosampler which draws 5ml of sample and adds internal standards and surrogate standards to achieve a 5ug/L concentration.

  For SIM analysis, internal and surrogate standards are spiked at 0.4μg/L, except 1,4-Dioxane which is spiked at 50 μg/L.
- If the concentration for any quantitation ion exceeds the initial calibration range of the GC/MS system, the sample extract should be diluted and reanalyzed. In any event, a result based on an extrapolation of calibration curve beyond the working range is flagged on the analytical report.
- The Extracted Ion Current Profile (EICP) area for all of the internal standards in all spikes, blanks, and samples is monitored relative to the most recent calibration verification standard. Changes by more than a factor of two (*i.e.* 50% to 200%) can indicate adverse matrix effects (in the case of an isolated sample) or degrading MS performance (in the case of a systematic low bias). A single-sample matrix effect is documented either via screening or re-analysis and is noted on the analytical report (see Table 5a and 5b). Similarly, the retention times for all of the internal standards in all spikes, blanks, and samples is monitored relative to the most recent calibration verification standard. The change in retention time for any internal standard by more

than 30 seconds of the most recent calibration verification standard is indicative of the same potential problems listed above and should be flagged/corrected as appropriate.

Qualitative analysis.

- The qualitative identification of compounds determined by this method is based on retention time and on comparison of the sample mass spectrum, after background correction, with characteristic ions in a reference mass spectrum. The reference mass spectrum must be generated by the laboratory using the conditions of this method. The characteristic ions from the reference mass spectrum are given in Figures 1a and 1b. Compounds are identified when the following criteria are met.
    - Initial selection of a target compound peak is performed by the Chemstation data system search routine. The search is based on the presence of a target chromatographic peak containing ions specific for the target compound at a compound specific retention time.
    - The RRT of the sample component is within ± 0.06 RRT units of the RRT of the standard component. This is accomplished using retention time extraction windows within the Chemstation data system.
    - The relative intensities of the characteristic ions agree within 30% of the relative intensities of these ions in the reference spectrum. (Example: For an ion with an abundance of 50% in the reference spectrum, the corresponding abundance in a sample spectrum can range between 20% and 80%.)
    - Structural isomers that produce very similar mass spectra are identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.
    - Identification is hampered when sample components are not resolved chromatographically and produce mass spectra containing ions contributed by more than one analyte. When gas chromatographic peaks obviously represent more than one sample component (*i.e.*, a broadened peak with shoulder(s) or a valley between two or more maxima), appropriate selection of analyte spectra and background spectra is important.
    - Examination of extracted ion current profiles of appropriate ions can aid in the selection of spectra and in qualitative identification of compounds. When analytes coelute (*i.e.*, only one chromatographic peak is apparent), the identification criteria may be met, but

each analyte spectrum will contain extraneous ions contributed by the coeluting compound.

- In the two previous cases, analyst expertise as well as knowledge of site history may be important in accepting/rejecting the identification of a compound. In the event of continued uncertainty, the analyst should preferentially make a conservative judgment and accept an identified hit, allowing the potential for a false positive.

♦ For samples containing components not associated with the calibration standards, a library search may be made for the purpose of tentative identification. The necessity to perform this type of identification will be determined by the purpose of the analyses being conducted. Only after visual comparison of sample spectra with the nearest library searches may the analyst assign a tentative identification. Guidelines for tentative identification are:

- Relative intensities of major ions in the reference spectrum (ions > 10% of the most abundant ion) should be present in the sample spectrum.
- The relative intensities of the major ions should agree within ± 20%.
- Molecular ions present in the reference spectrum should be present in the sample spectrum.
- Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of coeluting compounds.
- Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

Quantitative analysis.

♦ Once a compound has been identified, the quantitation of that compound will be based on the integrated abundance of the primary characteristic ion from the EICP.

♦ The curve fit applied in the initial calibration is the same as that used to compute the concentration of a target analyte in a sample. All curve fits are evaluated by the data system and are of the form: $A_s/A_i = k_0 + k_1[C_s/C_i] + k_2[C_s/C_i]^2$. Here A_s and A_i are the areas of the target and internal standard, C_s and C_i are the concentrations of the target and internal standard, and k_i is the i^{th}-order regression coefficient. Note that for a mean RF fit to the calibration data, $k_1 \equiv$ <RF>, while k_0, $k_2 \equiv 0$.

- The concentration of any non-target analytes identified in the sample may be estimated by assuming a mean RF of 1 and by using the tentatively identified compound (TIC) areas for the nearest internal standard and target compound. The resulting concentration should be reported indicating: (1) that the value is an estimate, and (2) which internal standard was used to determine concentration. Use the nearest internal standard free of interferences.
- Structural isomers that produce very similar mass spectra should be quantitated as individual isomers if they have sufficiently different GC retention times. Otherwise, structural isomers are quantitated as isomeric pairs (such as p- and m-xylene).

8.0 QUALITY CONTROL

All of the quality control items employed and evaluated are provided in Table 5a and 5b. In addition, the table indicates the frequency of each QC item along with appropriate courses of corrective action. Control limits for surrogates and internal standards are listed in Table 6. The analyst will follow SOP # QA-007 and complete the appropriate review form upon completion of the analysis.

9.0 METHOD PERFORMANCE

The precision and accuracy of the method depends upon the overall performance of the sample preparation and analysis. Laboratory specific performance data is provided for Merit's LIMs system. Each sample batch contains a method blank, laboratory control sample and matrix spike samples. Performance Evaluation samples are analyzed periodically in order to prove the performance of the method.

10.0 EQUIPMENT MAINTENANCE AND TROUBLESHOOTING

Each instrument is assigned a maintenance logbook. All maintenance performed on the instrument must be recorded. Additionally, any modifications to the instrument settings shall be noted in the specific instrument logbook. Maintenance procedures provided in the equipment manual shall be followed. Maintenance may include, cleaning the MS source, clipping/replacing the column, or replacing the calibration standard.

Computer software and firmware can be found on Merit's network at F:\data\MERIT\EQUIPMENT\Instrument-Software Version List.200818.xls.

11.0 SAFETY

Eye protection and gloves must be worn while performing the analyses. Every laboratory area has eyewash, emergency shower, and fire extinguisher. The metals lab also has dust masks available for use with dust samples. The air system throughout the laboratory area is on a 100% fresh air exchange system,

this system exchanges 100% the air in the laboratory area with air from outside 6 times per hour and 30 times per hour when the emergency purge button is hit.

A reference file of material safety data sheets (MSDSs) is available to all personnel. Specific attention shall be paid (but not limited) to:

a. Methanol may react violently with acids, acid chlorides, acid anhydrides, oxidizing agents, reducing agents and alkali metals. Protect from moisture. Highly flammable.
b. Hydrochloric acid is corrosive. Extreme heat or contact with metals can release flammable hydrogen gas, stable under ordinary conditions of use and storage, and incompatible with many substances and highly reactive with strong bases, metals, metal oxides, hydroxides, amines, carbonates, cyanides, sulfides, sulfites, and formaldehyde.

12.0 WASTE DISPOSAL AND POLLUTION PREVENTION

All laboratory waste must be managed, stored, and disposed in accordance with all federal and state laws and regulations. Additional information can be found in the Sample Disposal SOP and Merit's Waste Management Plan and Handbook.

13.0 DEFINITIONS

4-Bromofluorobenzene (BFB), is used to verify that the GC/MS is properly tuned and ready for calibration and sample analyses. BFB is directly injected at 25-50 ng and precedes all other analyses. A twelve hour analysis time window is used before another BFB injection is required.

An Initial Calibration Verification standard (ICV) is analyzed before the analysis of samples as a check on the calibration curve. The ICV shall be of a second source, meaning a separate vendor and/or lot # shall be used to prepare this standard. A second source is needed to validate the integrity and concentration of the standards used for calibration.

An Initial Calibration Blank (ICB) is also analyzed before samples to confirm that the deionized water (DI H2O) used for standards, blanks, and dilutions are free from contamination. An ICB for soil samples also includes organic free sand and/or methanol used for standard and QC preparation, as well as sample dilutions and volume adjustments; the control sand and methanol must also be documented as free from contamination.

A Calibration Check Verification standard (CCV) is analyzed at the beginning of each sequence (following the BFB injection) shift and every 12 hour shift thereafter. A CCV is made up from the same standards used

for calibration and is used to ensure that the calibration and retention times are stable.

An analytical batch is defined as a group of samples (not to exceed 20 samples) analyzed per sequential run. Depending on client or program requirements, an analytical batch may or may not include matrix spikes as part of the 20 samples.

Internal standards (ISTD) are added to each sample, blank, spike, and check standard. The ISTDs used are Fluorobenzene, Chlorobenzene-d_5, and 1,4-Dichlorobenzene-d_4. The ISTD is used for internal calibration as a reference peak and to check purging efficiency.

Surrogate standards (SSTD) are also added to each sample, blank, spike, and check standard. The SSTDs used are Toluene-d_4, 4-Bromofluorobenzene, 1,2-Dichloroethane-d_4, and Dibromofluoromethane. The SSTD is used as matrix interference and as a method control check.

Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

A Continuing Calibration Blank (CCB) is analyzed every 12 hour shift after the MB has been analyzed and before sample reanalyzes to ensure the system is still free from contamination.

Instrument blanks are analyzed whenever instrument contamination is a suspected possibility. The purpose of an IB is to prevent carry over from a standard, spike, or contaminated sample into another sample or blank. The acceptance criteria for an IB is the same as for a MB or CCB (for example: if an IB contains detections above acceptance criteria and a MB and/or sample following the IB exhibit the same contamination above acceptance criteria, then the instrument shall be considered contaminated). The samples and/or MBs shall be reanalyzed after the instrument is confirmed free from contamination.

Laboratory Control Spike (LCS): Milli-Q water (for water) and Organic-Free Soil (for soil) is spiked with all target compounds and carried through the complete sample preparation and analytical procedure. The control spike is used to document the ability of an analyst to generate acceptable precision and bias to verify the analytical system performance, and to document method accuracy for each matrix.

Matrix Spike (MS): An aliquot of sample spiked with all target compounds. The spiking occurs prior to sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.

Matrix Spike Duplicate (MSD): Intra-laboratory split samples spiked with all target compounds. The spiking occurs prior to sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.

14.0 REFERENCES

Bellar, T., *Measurement of Volatile Organic Compounds in Soils Using Modified Purge-and-Trap and Capillary Gas Chromatography/Mass Spectrometry*, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Cincinnati, OH, November, 1991.

Department of Defense, Quality Systems Manual for Environmental Laboratories (DoD QSM), DoD Environmental Data Quality Workgroup, Department of Navy, Lead Service, Version 5.4, 2021

U.S. EPA 40 CFR Part 136, *Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule,* October 26, 1984.

EPA SW-846, *Test Methods for Evaluation Solid Waste*, 3rd Edition, Update I dated 7/92, Update II dated 9/94, Update IIA dated 8/93, Update IIB dated 1/95, Update III dated 12/96, Update IV dated 1/08.

International Standards Organization (ISO), 2005. *General Requirements for the Competence of Testing and Calibration Laboratories.* ISO 17025.

National Environmental Laboratory Accreditation Conference (NELAC), 2003. *Standards, Chapters 1–6*, EPA/600/R-04/003.

EPA Method 624.1, December 2016

Table 1. Summary of Retention Times and Characteristic Ions for Volatile Organics

Compound List Report Ravnica

Method : F:\GCMS.DAT\RAVNICA.SN\METHODS\WR201119.M
Title : Volatile Organics, SW-846 # 8260B
Last Update : Thu Nov 19 18:19:17 2020
Response via : Initial Calibration
Total Cpnds : 88

PK#		Compound Name	QIon	Exp_RT	Rel_RT	Cal	#Qual	A/H	ID
1	I	PENTAFLUOROBENZENE (I)	168	4.04	1.000	A	2	A	B
2	S	1,2-DICHLOROETHANE-D4 (S)	65	4.19	1.039	A	2	A	B
3		1,1,2-Trichloro-1,2,2-trifluor	101	2.63	0.651	A	2	A	B
4		Diethyl ether (*)	74	2.41	0.596	A	2	A	B
5		Acetone (*)	43	2.66	0.660	A	2	A	B
6		Methyl iodide (iodomethane) (*	142	2.70	0.669	A	2	A	B
7		Carbon disulfide (*)	76	2.76	0.684	A	2	A	B
8		Methyl Acetate	43	2.91	0.721	A	2	A	B
9		tert-Methyl butyl ether (MTBE)	73	3.17	0.784	A	3	A	B
10		Acrylonitrile (*)	53	3.15	0.780	A	2	A	B
11		2-Butanone (MEK) (*)	43	3.77	0.935	A	2	A	B
12		Dichlorodifluoromethane	85	1.26	0.311	QO	2	A	B
13		Chloromethane (SPCC)	50	1.34	0.332	A	2	A	B
14		Vinyl Chloride (CCC)	62	1.47	0.365	A	2	A	B
15		Bromomethane	94	1.75	0.432	A	2	A	B
16		Chloroethane	64	1.85	0.458	A	3	A	B
17		Acrolein	56	2.52	0.623	A	2	A	B
18		Trichlorofluoromethane	101	2.17	0.538	A	3	A	B
19		1,1-Dichloroethene (CCC/MS)	61	2.58	0.639	A	3	A	B
20		Methylene Chloride	84	2.97	0.736	A	3	A	B
21		trans-1,2-Dichloroethene	61	3.16	0.782	A	3	A	B
22		Hexane	57	3.33	0.825	A	2	A	B
23		Vinyl Acetate	43	3.32	0.823	A	2	A	B
24		1,1-Dichloroethane (SPCC)	63	3.42	0.848	A	2	A	B
25		cis-1,2-Dichloroethene	96	3.76	0.932	A	2	A	B
26		2,2-Dichloropropane	77	3.76	0.932	A	2	A	B
27		Tetrahydrofuran	42	3.92	0.970	A	2	A	B
28		Chloroform (CCC)	83	3.94	0.975	A	2	A	B
29		Bromochloromethane	130	3.90	0.965	A	3	A	B
30		1,1,1-Trichloroethane	97	4.04	1.000	A	2	A	B
31		1,1-Dichloropropene	75	4.11	1.018	A	2	A	B
32		Cyclohexane	42	4.06	1.005	A	3	A	B
33	I	1,4-DIFLUOROBENZENE (I)	114	4.40	1.000	A	2	A	B
34	S	TOLUENE-D8 (S)	98	5.11	1.160	A	2	A	B
35		4-Methyl-2-pentanone (MIBK) (*	58	5.04	1.145	A	3	A	B
36		2-Hexanone (*)	58	5.43	1.232	A	3	A	B
37		2-chloroethylvinyl ether	63	4.90	1.113	A	2	A	B
38		Carbon Tetrachloride	117	4.12	0.936	A	2	A	B
39		Benzene (MS)	78	4.22	0.958	A	2	A	B
40		1,2-Dichloroethane	62	4.23	0.961	A	3	A	B
41	M	Trichloroethene (MS)	95	4.53	1.030	A	3	A	B
42		1,2-Dichloropropane (CCC)	63	4.64	1.055	A	2	A	B
43		Bromodichloromethane	83	4.77	1.083	A	3	A	B
44		Methyl Cyclohexane	55	4.63	1.051	A	3	A	B
45		Dibromomethane	174	4.71	1.069	A	3	A	B
46		cis-1,3-Dichloropropene	75	4.98	1.131	A	2	A	B
47	M	Toluene (CCC/MS)	91	5.14	1.167	A	2	A	B
48		trans-1,3-Dichloropropene	75	5.23	1.188	A	2	A	B

49	1,1,2-Trichloroethane	83	5.32	1.208	A	3	A	B
50	Tetrachloroethene	166	5.39	1.225	A	2	A	B
51 I	CHLOROBENZENE-D5 (I)	82	5.78	1.000	A	2	A	B
52 S	4-BROMOFLUOROBENZENE (S)	174	6.33	1.095	A	2	A	B
53	1,3-Dichloropropane	76	5.40	0.935	A	2	A	B
54	trans-1,4-Dichloro-2-butene	53	6.41	1.109	QO	3	A	B
55	Dibromochloromethane	129	5.51	0.954	A	2	A	B
56	1,2-Dibromoethane	107	5.57	0.965	A	2	A	B
57 M	Chlorobenzene (SPCC/MS)	112	5.79	1.003	A	2	A	B
58	1,1,1,2-Tetrachloroethane	131	5.83	1.009	A	3	A	B
59	Ethylbenzene (CCC)	91	5.84	1.010	A	2	A	B
60	p,m-Xylene	106	5.89	1.019	A	2	A	B
61	o-Xylene	91	6.08	1.052	A	2	A	B
62	Styrene	104	6.08	1.053	A	2	A	B
63	Isopropylbenzene	105	6.24	1.081	A	2	A	B
64	Bromoform (SPCC)	173	6.18	1.070	A	2	A	B
65	1,1,2,2-Tetrachloroethane (SPC	83	6.38	1.104	A	3	A	B
66	1,2,3-Trichloropropane	110	6.41	1.110	A	3	A	B
67	n-Propylbenzene	91	6.44	1.114	A	2	A	B
68	Bromobenzene	156	6.41	1.109	A	2	A	B
69	1,3,5-Trimethylbenzene	120	6.52	1.128	A	2	A	B
70	2-Chlorotoluene	91	6.49	1.123	A	2	A	B
71	4-Chlorotoluene	126	6.54	1.132	A	2	A	B
72	tert-Butylbenzene	91	6.67	1.155	A	2	A	B
73	1,2,4-Trimethylbenzene	120	6.70	1.160	A	2	A	B
74 I	1,4-DICHLOROBENZENE-D4 (I)	152	6.88	1.000	A	2	A	B
75	sec-Butylbenzene	105	6.78	0.986	A	2	A	B
76	p-Isopropyltoluene	119	6.84	0.995	A	2	A	B
77	1,3-Dichlorobenzene	146	6.85	0.995	A	2	A	B
78	1,4-Dichlorobenzene	146	6.89	1.002	A	2	A	B
79	1,2-Dichlorobenzene	146	7.07	1.028	A	2	A	B
80	1,2,3-Trimethylbenzene	105	6.90	1.004	A	2	A	B
81	n-Butylbenzene	91	7.04	1.024	A	2	A	B
82	Hexachloroethane	201	7.19	1.046	A	2	A	B
83	1,2-Dibromo-3-Chloropropane	157	7.44	1.082	A	3	A	B
84	1,2,4-Trichlorobenzene	182	7.84	1.140	A	3	A	B
85	Hexachlorobutadiene	225	7.92	1.151	A	3	A	B
86	1,2,3-Trichlorobenzene	180	8.09	1.176	A	3	A	B
87	Naphthalene	128	7.97	1.159	A	3	A	B
88	2-Methylnaphthalene	142	8.52	1.239	A	2	A	B

Cal A = Average L = Linear LO = Linear w/origin Q = Quad QO = Quad w/origin
#Qual = number of qualifiers
A/H = Area or Height
ID R = R.T. B = R.T. & Q Q = Qvalue L = Largest A = All

WR201119.M Fri Dec 18 09:41:56 2020

: For DoD projects, all target compounds will be included in the matrix spike and matrix spike duplicate

Table 2. Summary of Applicable Performance Compounds - Volatile Organics Analysis

COMPOUND	ISD	SSD
PENTAFLUOROBENZENE	✔	
1,2-DICHLOROETHANE-D4		✔
1,4-DIFLUOROBENZENE	✔	
TOLUENE-D8		✔
CHLOROBENZENE-D5	✔	
4-BROMOFLUOROBENZENE-		✔
1,4-DICHLOROBENZENE-D4	✔	

: For DoD projects, all target compounds will be included in the matrix spike and matrix spike duplicate

Key

ISD: Internal Standard Compound

SSD: Surrogate Standard Compound

Table 2b. Recommended Minimum Relative Response Factor Criteria For Initial And Continuing Calibration Verification.

Volatile Compounds	Minimum Response Factor (RF)[a]
Dichlorodifluoromethane	0.100
Chloromethane	0.100
Vinyl chloride	0.100
Bromomethane	0.100
Chloroethane	0.100
Trichlorofluoromethane	0.100
1,1-Dichloroethene	0.100
1,1,2-Trichloro-1,2,2-trifluoroethane	0.100
Acetone	0.100
Carbon disulfide	0.100
Methyl Acetate	0.100
Methylene chloride	0.100
trans-1,2-Dichloroethene	0.100
cis-1,2-Dichloroethene	0.100
Methyl tert-Butyl Ether	0.100
1,1-Dichloroethane	0.200
2-Butanone	0.100
Chloroform	0.200
1,1,1-Trichloroethane	0.100
Cyclohexane	0.100
Carbon tetrachloride	0.100
Benzene	0.500
1,2-Dichloroethane	0.100
Trichloroethene	0.200
Methylcyclohexane	0.100
1,2-Dichloropropane	0.100
Bromodichloromethane	0.200
cis-1,3-Dichloropropene	0.200
trans-1,3-Dichloropropene	0.100
4-Methyl-2-pentanone	0.100
Toluene	0.400
1,1,2-Trichloroethane	0.100
Tetrachloroethene	0.200
2-Hexanone	0.100
Dibromochloromethane	0.100
1,2-Dibromoethane	0.100
Chlorobenzene	0.500

Volatile Compounds	Minimum Response Factor (RF)[a]
Ethylbenzene	0.100
meta-/para-Xylene	0.100
ortho-Xylene	0.300
Styrene	0.300
Bromoform	0.100
Isopropylbenzene	0.100
1,1,2,2-Tetrachloroethane	0.300
1,3-Dichlorobenzene	0.600
1,4-Dichlorobenzene	0.500
1,2-Dichlorobenzene	0.400
1,2-Dibromo-3-chloropropane	0.050
1,2,4-Trichlorobenzene	0.200

[a] The Project-specific response factors obtained may be affected by the quantitation ion selected and when using possible alternate ions the actual response factors may be lower than those listed.

Table 3. GC/MS Operating Conditions - Volatile Organics Analysis

Operating Parameter	**Volatiles Analysis**
Chromatographic Column	DB 624, *L* = 20 *m*, *ID* = 0.18 *mm*
Carrier Gas	Helium (He)
Temperature Program	T_0 = 30°C, hold 2.0 *min* dT/dt_1 = 32°C/*min* T_1 = 195°C dT/dt_2 = 30°C/*min* T_2 = 235°C
Injector Temperature	150°C
Detector Temperature	300°C
Purge Volume	5 *mL*
Mass Scanning Range	35 *m/z* - 260 *m/z*
Mass Scanning Rate	2.0 *Hz*

Note: the above is subject to change based on GC and/or sample conditions.

Table 4. BFB Tune Evaluation Criteria

Target *m/z*	**Relative *m/z***	**LCL (%)**	**UCL (%)**
50	95	8	40
75	95	30	66
95	95	100	100
96	95	5.0	9.0
173	174	0	2.0
174	95	50	120
175	174	4.0	9.0
176	174	93	101
177	176	5.0	9.0

Abundance criteria are for a quadrupole mass spectrometer. Alternative tuning criteria from other published EPA reference methods may be used, provided method performance is not adversely affected. Alternative tuning criteria specified by an instrument manufacturer may also be used for another type of mass spectrometer, or for an alternative carrier gas, provided method performance is not adversely affected.

Table 5a. Quality Control Items, Frequency, and Corrective Action

QC Item	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration	Prior to all analytical runs	Method-based	Examine the entire analytical system; some or all of the following: clean MS source, re-tune, clip/replace column, replace calibration standards, re-calibrate.
BFB	12-hour	Table 4	Re-attempt injection; clean MS source, re-tune; failure requires the re-analysis of all associated analytical runs.
Calibration Verification	12-hour	Table 2b	Re-attempt injection; some or all of the following: clean MS source, re-tune, clip/replace column, replace calibration standards, re-calibrate; failure requires the re-analysis of all associated analytical runs.
LCS and MS	20 samples	Laboratory in-house Control Limits with no more than 4 Marginal Exceedances	A failed LCS should be re-analyzed. A failed MS requires no action provided that the LCS is acceptable. If additional sample exists, the samples associated with a failed LCS should be re-analyzed or QC data qualified.
Duplicate or MSD	20 samples	n/a	Relative Percent Differences (RPDs) are computed and included in the QC report
Method Blank	20 samples	<RL	Method blank contamination is flagged on the analytical report for any identified target compound. Blanks indicative of contaminated analytical system (typically the purge-and-trap system) should result in a thorough cleansing of the affected system and sample/blank re-analysis.
Internal Standard	All samples	Section 7.5.5	Adverse matrix effects on areas/recoveries are demonstrated either by screening the extract of re-analyzing the sample within a 12-hour QC batch.

QC Item	Frequency	Acceptance Criteria	Corrective Action
			The resulting analytical report is flagged appropriately. A negative bias unrelated to matrix effects indicates the need to: clean the MS source, re-tune, and re-calibrate
Surrogate Standard	All samples	Table 6	Adverse matrix effects on areas/recoveries are demonstrated either by screening the extract of re-analyzing the sample within a 12-hour QC batch. The resulting analytical report is flagged appropriately. If additional sample exists, the sample should be re-extracted prior to re-analysis if a matrix effect cannot be demonstrated.
Target Compound	All samples	Method-based	Target compounds beyond the calibration range are diluted and re-analyzed and/or flagged as estimated on the analytical report.

Table 5b. Quality Control Items, Frequency, and Corrective Action for DoD Projects

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Tune Check	Prior to ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify.	Flagging is not appropriate.	No samples shall be analyzed without a valid tune.
Initial calibration (ICAL) for all analytes (including surrogates)	At instrument set-up and after ICV or CCV failure, prior to sample analysis.	Each analyte must meet one of the three options below: Option 1: RSD for each analyte ≤ 15%; Option 2: linear least squares regression for each analyte: r2 ≥ 0.99; Option 3: non-linear least squares regression (quadratic) for each analyte: r2 ≥ 0.99.	Correct problem then repeat ICAL.	Flagging is not appropriate.	Minimum 5 levels for linear and 6 levels for quadratic. No samples shall be analyzed until ICAL has passed. If the specific version of a method requires additional evaluation (e.g., RFs or low calibration standard analysis and recovery criteria) these additional requirements must also be met.
Retention Time window position establishment	Once per ICAL and at the beginning of the analytical sequence.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA.	NA.	Calculated for each analyte and surrogate.
Evaluation of Relative Retention Times (RRT)	With each sample.	RRT of each reported analyte within ± 0.06 RRT units.	Correct problem, then rerun ICAL.	NA.	After maintenance is performed which may affect retention times, RRTs may be updated based on the daily CCV. RRTs shall be compared with the most recently updated RRTs.
Initial	Once after	All reported	Correct problem.	Flagging is not	No samples shall be analyzed

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Calibration Verification (ICV)	each ICAL, analysis of a second source prior to sample analysis	analytes within ± 20% of true value.	Rerun ICV. If that fails, repeat ICAL.	appropriate.	until calibration has been verified with a second source.
Continuing calibration verification (CCV)	Daily before sample analysis; after every 12 hours of analysis time; and at the end of the analytical batch run.	All reported analytes and surrogates within ± 20% of true value. All reported analytes and surrogates within ± 50% for end of analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since the last acceptable CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since last acceptable calibration verification.	Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. If the specific version of a method requires additional evaluation (e.g, average RFs) these additional requirements must also be met.
Internal standards (IS)	Every field sample, standard, and QC sample.	Retention time ± 10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions and correct problem. Reanalysis of samples analyzed while system was malfunctioning is	If corrective action fails in field samples, data must be qualified and explained in the case narrative. Apply Q-flag	NA

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
		On days when ICAL is not performed, the daily initial CCV can be used.	mandatory.	to analytes associated with the non-compliant IS. Flagging criteria is not appropriate for failed standards.	
Method blank (MB)	One per preparatory batch.	No analytes detected > ½ LOQ or > 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater. Common contaminants, must not be detected > LOQ.	Correct problem. If required, reprep and reanalyze MB and all QC samples and field samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Laboratory Control Sample (LCS)	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory	Must contain all surrogates and all analytes to be reported. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
				batch.	
Matrix Spike (MS)	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the case narrative.	Must contain all surrogates and all analytes to be reported. For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference, i.e., matrix effect or analytical error.
Matrix spike duplicate (MSD) or Matrix duplicate (MD)	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. MSD or MD: RPD of all analytes ≤ 20% (between MS and MSD or sample and MD).	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the case narrative.	MSD: Must contain all surrogates and all analytes to be reported. The data shall be evaluated to determine the source of difference. For Sample/MD: RPD criteria only apply to analytes whose concentration in the sample is greater than or equal to the LOQ.
Surrogate spike	All field and QC samples.	QC acceptance criteria specified by project, if available; otherwise use QSM Appendix C limits or in-house LCS limits if analyte(s) are not listed..	Correct problem, then reprep and reanalyze all failed samples for all surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious	Apply Q-flag to all associated analytes if acceptance criteria are not met and explain in the case narrative.	Alternative surrogates are recommended when there is obvious chromatographic interference.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
			chromatographic interference with surrogate is present, reanalysis may not be necessary, but the client must be notified prior to reporting data and the failures must be discussed in the Case Narrative.		

DoD Appendix C LCS Limits
Method 8260 Solid Matrix

CAS ID	ANALYTE	LOWER CONTROL LIMIT (LCL)	UPPER CONTROL LIMIT (UCL)
630-20-6	1,1,1,2-Tetrachloroethane	78	125
71-55-6	1,1,1-Trichloroethane	73	130
79-34-5	1,1,2,2-Tetrachloroethane	70	124
79-00-5	1,1,2-Trichloroethane	78	121
76-13-1	1,1,2-Trifluoro-1,2,2-trichloroethane [Freon-113]	66	136
75-34-3	1,1-Dichloroethane	76	125
75-35-4	1,1-Dichloroethene	70	131
563-58-6	1,1-Dichloropropene	76	125
87-61-6	1,2,3-Trichlorobenzene	66	130
96-18-4	1,2,3-Trichloropropane	73	125
526-73-8	1,2,3-Trimethlybenzene	82	118
120-82-1	1,2,4-Trichlorobenzene	67	129
95-63-6	1,2,4-Trimethylbenzene	75	123
96-12-8	1,2-Dibromo-3-chloropropane	61	132
106-93-4	1,2-Dibromoethane	78	122
95-50-1	1,2-Dichlorobenzene	78	121
107-06-2	1,2-Dichloroethane	73	128
17060-07-0	1,2-Dichloroethane-d4	71	136
540-59-0	1,2-Dichloroethene	78	122
78-87-5	1,2-Dichloropropane	76	123
354-23-4	1,2-Dichlorotrifluoroethane [Freon 123a]	64	132
108-70-3	1,3,5-Trichlorobenzene	71	128
108-67-8	1,3,5-Trimethylbenzene	73	124
541-73-1	1,3-Dichlorobenzene	77	121
142-28-9	1,3-Dichloropropane	77	121
542-75-6	1,3-Dichloropropene	77	126
106-46-7	1,4-Dichlorobenzene	75	120
105-05-5	1,4-Diethylbenzene	79	114

123-91-1	1,4-Dioxane	55	138
544-10-5	1-Chlorohexane	71	130
594-20-7	2,2-Dichloropropane	67	133
78-93-3	2-Butanone (MEK)	51	148
126-99-8	2-Chloro-1,3-butadiene	65	133
110-75-8	2-Chloroethyl vinyl ether	43	149
95-49-8	Chlorotoluene	75	122
591-78-6	2-Hexanone	53	145
79-46-9	2-Nitropropane	47	150
67-63-0	2-Propanol [Isopropyl alcohol]	60	140
460-00-4	4-Bromofluorobenzene	79	119
106-43-4	4-Chlorotoluene	72	124
108-10-1	4-Methyl-2-pentanone [MIBK]	65	135
67-64-1	Acetone	36	164
75-05-8	Acetonitrile	54	143
107-02-8	Acrolein [Propenal]	47	155
107-13-1	Acrylonitrile	65	134
107-05-1	Allyl chloride	68	135
71-43-2	Benzene	77	121
100-44-7	Benzyl chloride	64	120
108-86-1	Bromobenzene	78	121
74-97-5	Bromochloromethane	78	125
75-27-4	Bromodichloromethane	75	127
75-25-2	Bromoform	67	132
74-83-9	Bromomethane	53	143
75-15-0	Carbon disulfide	63	132
56-23-5	Carbon tetrachloride	70	135
108-90-7	Chlorobenzene	79	120
124-48-1	Chlorodibromomethane	74	126
75-00-3	Chloroethane	59	139
67-66-3	Chloroform	78	123
74-87-3	Chloromethane	50	136
156-59-2	cis-1,2-Dichloroethene	77	123

10061-01-5	cis-1,3-Dichloropropene	74	126
1476-11-5	cis-1,4-Dichloro-2-butene	69	143
110-82-7	Cyclohexane	67	131
108-94-1	Cyclohexanone	30	156
1868-53-7	Dibromofluoromethane	78	119
74-95-3	Dibromomethane	78	125
75-71-8	Dichlorodifluoromethane [Freon-12]	29	149
75-43-4	Dichlorofluoromethane	47	155
60-29-7	Diethyl ether	71	129
108-20-3	Diisopropyl ether	69	127
64-17-5	Ethanol	45	159
141-78-6	Ethyl acetate	52	139
97-63-2	Ethyl methacrylate	69	129
637-92-3	Ethyl tert-butyl ether	72	126
100-41-4	Ethylbenzene	76	122
462-06-6	Fluorobenzene	81	114
142-82-5	Heptane	49	138
87-68-3	Hexachlorobutadiene	61	135
67-72-1	Hexachloroethane	72	133
110-54-3	Hexane	45	142
74-88-4	Iodomethane	71	131
78-83-1	Isobutyl alcohol	60	135
108-21-4	Isopropyl acetate [Acetic acid]	58	131
98-82-8	Isopropylbenzene	68	134
179601-23-1	m/p-Xylene [3/4-Xylene]	77	124
126-98-7	Methacrylonitrile	66	132
79-20-9	Methyl acetate	53	144
80-62-6	Methyl methacrylate	63	134
1634-04-4	Methyl tert-butyl ether [MTBE]	73	125
108-87-2	Methylcyclohexane	66	133
75-09-2	Methylene chloride	70	128
123-86-4	n-Butyl acetate	62	128
71-36-3	n-Butyl alcohol	55	131

104-51-8	n-Butylbenzene	70	128
103-65-1	n-Propylbenzene	73	125
91-20-3	Naphthalene	62	129
95-47-6	o-Xylene	77	123
99-87-6	p-Isopropyltoluene [p-Cymene]	73	127
76-01-7	Pentachloroethane	69	135
107-12-0	Propionitrile [Ethyl cyanide]	68	134
135-98-8	sec-Butylbenzene	73	126
100-42-5	Styrene	76	124
994-05-8	tert-Amyl methyl ether [TAME]	73	126
75-65-0	tert-Butyl alcohol	68	133
98-06-6	tert-Butylbenzene	73	125
127-18-4	Tertachloroethene	73	128
109-99-9	Tetrahydrofuran	61	135
108-88-3	Toluene	77	121
2037-26-5	Toluene-d8	85	116
156-60-5	trans-1,2-Dichloroethene	74	125
10061-02-6	trans-1,3-Dichloropropene	71	130
110-57-6	trans-1,4-Dichloro-2-butene	62	136
79-01-6	Trichloroethene	77	123
75-69-4	Trichlorofluoromethane [Freon-11]	62	140
108-05-4	Vinyl acetate	50	151
75-01-4	Vinyl chloride	56	135
1330-20-7	Xylene [total]	78	124

DoD Appendix C LCS Limits
Method 8260 Water Matrix

CAS ID	ANALYTE	LOWER CONTROL LIMIT (LCL)	UPPER CONTROL LIMIT (UCL)
630-20-6	1,1,1,2-Tetrachloroethane	78	124
71-55-6	1,1,1-Trichloroethane	74	131
79-34-5	1,1,2,2-Tetrachloroethane	71	121
79-00-5	1,1,2-Trichloroethane	80	119
76-13-1	1,1,2-Trifluoro-1,2,2-trichloroethane	70	136

	[Freon-113]		
75-34-3	1,1-Dichloroethane	77	125
75-35-4	1,1-Dichloroethene	71	131
563-58-6	1,1-Dichloropropene	79	125
87-61-6	1,2,3-Trichlorobenzene	69	129
96-18-4	1,2,3-Trichloropropane	73	122
526-73-8	1,2,3-Trimethlybenzene	82	120
120-82-1	1,2,4-Trichlorobenzene	69	130
95-63-6	1,2,4-Trimethylbenzene	76	124
96-12-8	1,2-Dibromo-3-chloropropane	62	128
106-93-4	1,2-Dibromoethane	77	121
95-50-1	1,2-Dichlorobenzene	80	119
107-06-2	1,2-Dichloroethane	73	128
17060-07-0	1,2-Dichloroethane-d4	81	118
540-59-0	1,2-Dichloroethene	79	121
78-87-5	1,2-Dichloropropane	78	122
354-23-4	1,2-Dichlorotrifluoroethane [Freon 123a]	70	136
108-70-3	1,3,5-Trichlorobenzene	75	130
108-67-8	1,3,5-Trimethylbenzene	75	124
106-99-0	1,3-Butadiene	43	158
541-73-1	1,3-Dichlorobenzene	80	119
142-28-9	1,3-Dichloropropane	80	119
542-75-6	1,3-Dichloropropene	77	123
106-46-7	1,4-Dichlorobenzene	79	118
105-05-5	1,4-Diethylbenzene	79	118
123-91-1	1,4-Dioxane	59	139
544-10-5	1-Chlorohexane	76	124
540-84-1	2,2,4-Trimethylpentane [Isooctane]	58	132
594-20-7	2,2-Dichloropropane	60	139
75-85-4	2-Butanol	66	120
78-93-3	2-Butanone (MEK)	56	143
126-99-8	2-Chloro-1,3-butadiene	65	135

110-75-8	2-Chloroethyl vinyl ether	51	139
95-49-8	Chlorotoluene	79	122
591-78-6	2-Hexanone	57	139
91-57-6	2-Methylnaphthalene	17	142
79-46-9	2-Nitropropane	49	136
67-63-0	2-Propanol [Isopropyl alcohol]	56	142
624-95-3	3,3-Dimethyl-1-butanol	49	133
460-00-4	4-Bromofluorobenzene	85	114
106-43-4	4-Chlorotoluene	78	122
108-10-1	4-Methyl-2-pentanone [MIBK]	67	130
67-64-1	Acetone	39	160
75-05-8	Acetonitrile	50	142
107-02-8	Acrolein [Propenal]	39	155
107-13-1	Acrylonitrile	63	135
107-05-1	Allyl chloride	68	130
71-43-2	Benzene	79	120
100-44-7	Benzyl chloride	42	138
108-86-1	Bromobenzene	80	120
74-97-5	Bromochloromethane	78	123
75-27-4	Bromodichloromethane	79	125
75-25-2	Bromoform	66	130
74-83-9	Bromomethane	53	141
75-15-0	Carbon disulfide	64	133
56-23-5	Carbon tetrachloride	72	136
108-90-7	Chlorobenzene	82	118
124-48-1	Chlorodibromomethane	74	126
75-45-6	Chlorodifluoromethane	40	129
75-00-3	Chloroethane	60	138
67-66-3	Chloroform	79	124
74-87-3	Chloromethane	50	139
156-59-2	cis-1,2-Dichloroethene	78	123
10061-01-5	cis-1,3-Dichloropropene	75	124
1476-11-5	cis-1,4-Dichloro-2-butene	57	146

110-82-7	Cyclohexane	71	130
1868-53-7	Dibromofluoromethane	80	119
74-95-3	Dibromomethane	79	123
75-71-8	Dichlorodifluoromethane [Freon-12]	32	152
75-43-4	Dichlorofluoromethane	72	131
60-29-7	Diethyl ether	68	129
108-20-3	Diisopropyl ether	67	128
64-17-5	Ethanol	48	151
141-78-6	Ethyl acetate	55	138
97-63-2	Ethyl methacrylate	72	126
637-92-3	Ethyl tert-butyl ether	70	127
100-41-4	Ethylbenzene	79	121
462-06-6	Fluorobenzene	80	116
142-82-5	Heptane	49	140
87-68-3	Hexachlorobutadiene	66	134
67-72-1	Hexachloroethane	72	134
110-54-3	Hexane	48	143
74-88-4	Iodomethane	69	131
78-83-1	Isobutyl alcohol	63	133
108-21-4	Isopropyl acetate [Acetic acid]	63	133
98-82-8	Isopropylbenzene	72	131
179601-23-1	m/p-Xylene [3/4-Xylene]	80	121
126-98-7	Methacrylonitrile	63	133
79-20-9	Methyl acetate	56	136
80-62-6	Methyl methacrylate	67	128
1634-04-4	Methyl tert-butyl ether [MTBE]	71	124
108-87-2	Methylcyclohexane	72	132
75-09-2	Methylene chloride	74	124
123-86-4	n-Butyl acetate	69	125
71-36-3	n-Butyl alcohol	59	131
104-51-8	n-Butylbenzene	75	128
109-60-4	n-Propyl acetate	76	126
103-65-1	n-Propylbenzene	76	126

91-20-3	Naphthalene	61	128
95-47-6	o-Xylene	78	122
99-87-6	p-Isopropyltoluene [p-Cymene]	77	127
76-01-7	Pentachloroethane	69	133
109-66-0	Pentane	16	134
107-12-0	Propionitrile [Ethyl cyanide]	64	136
135-98-8	sec-Butylbenzene	77	126
100-42-5	Styrene	78	123
994-05-8	tert-Amyl methyl ether [TAME]	68	128
75-65-0	tert-Butyl alcohol	68	129
762-75-4	tert-Butyl formate	65	132
98-06-6	tert-Butylbenzene	78	124
127-18-4	Tertachloroethene	74	129
109-99-9	Tetrahydrofuran	57	133
108-88-3	Toluene	80	121
2037-26-5	Toluene-d8	89	112
156-60-5	trans-1,2-Dichloroethene	75	124
10061-02-6	trans-1,3-Dichloropropene	73	127
110-57-6	trans-1,4-Dichloro-2-butene	43	140
79-01-6	Trichloroethene	79	123
75-69-4	Trichlorofluoromethane [Freon-11]	65	141
108-05-4	Vinyl acetate	54	146
75-01-4	Vinyl chloride	58	137
1330-20-7	Xylene [total]	79	121

LCS Limits
EPA 624.1 Water Matrix

CAS ID	ANALYTE	LOWER CONTROL LIMIT (LCL)	UPPER CONTROL LIMIT (UCL)
71-55-6	1,1,1-Trichloroethane	70	130
79-34-5	1,1,2,2-Tetrachloroethane	60	140
79-00-5	1,1,2-Trichloroethane	70	130
75-34-3	1,1-Dichloroethane	70	130
75-35-4	1,1-Dichloroethene	50	150
95-50-1	1,2-Dichlorobenzene	65	135
107-06-2	1,2-Dichloroethane	70	130
78-87-5	1,2-Dichloropropane	35	165
541-73-1	1,3-Dichlorobenzene	70	130
106-46-7	1,4-Dichlorobenzene	65	135
110-75-8	2-Chloroethyl vinyl ether	0	225
107-02-8	Acrolein [Propenal]	60	140
107-13-1	Acrylonitrile	60	140
71-43-2	Benzene	65	135
75-27-4	Bromodichloromethane	65	135
75-25-2	Bromoform	70	130
74-83-9	Bromomethane	15	185
56-23-5	Carbon tetrachloride	70	130
108-90-7	Chlorobenzene	65	135
124-48-1	Chlorodibromomethane	70	135
75-00-3	Chloroethane	40	160
67-66-3	Chloroform	70	135
74-87-3	Chloromethane	0	205
10061-01-5	cis-1,3-Dichloropropene	25	175
100-41-4	Ethylbenzene	60	140
75-09-2	Methylene chloride	60	140
127-18-4	Tetrachloroethene	70	130
108-88-3	Toluene	70	130
156-60-5	trans-1,2-Dichloroethene	70	130

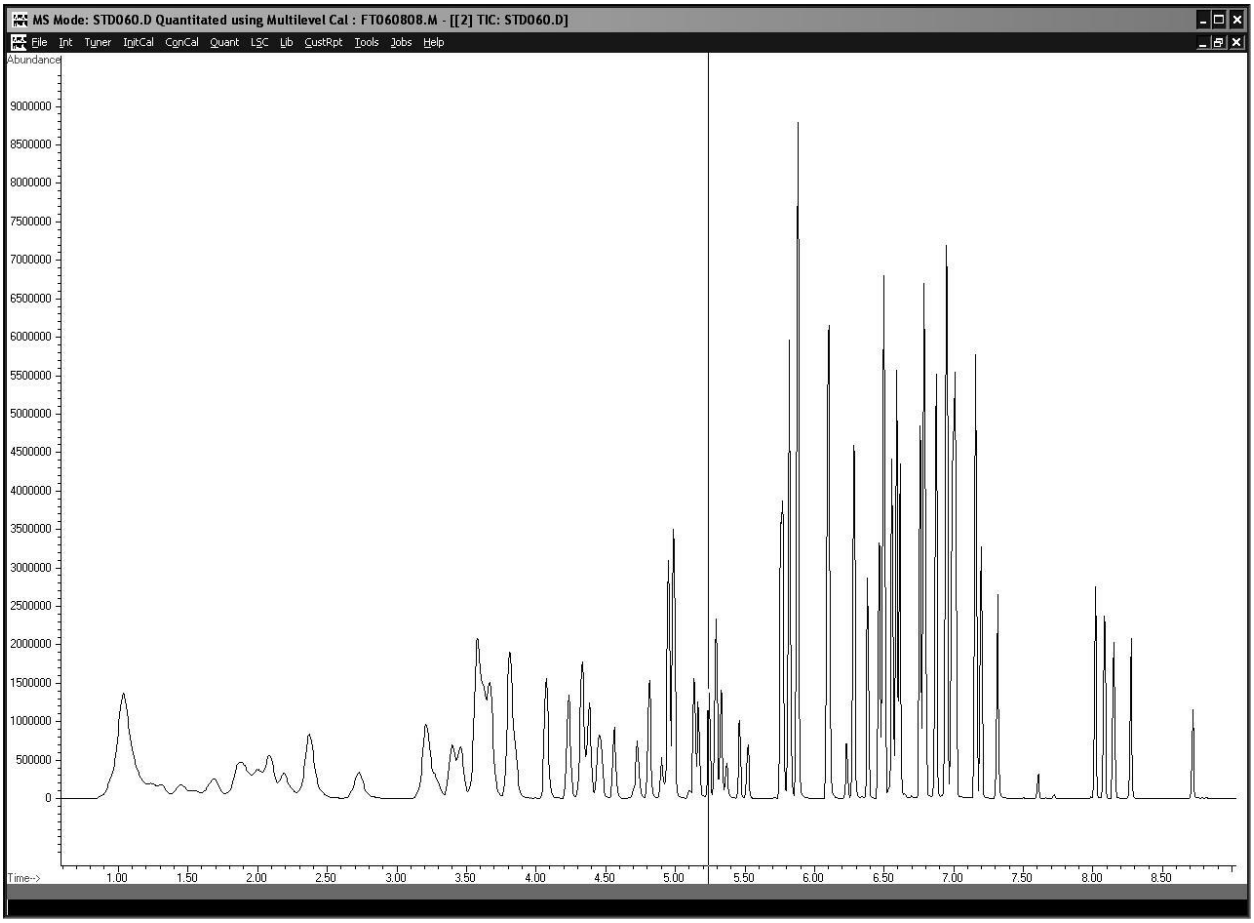
10061-02-6	trans-1,3-Dichloropropene	50	150
79-01-6	Trichloroethene	65	135
75-69-4	Trichlorofluoromethane [Freon-11]	50	150
75-01-4	Vinyl chloride	5	195

Table 6. Summary of Control Limits: Surrogate and Internal Standard Compounds Percent Recovery†

COMPOUND	Water Matrix		Solid Matrix	
	LCL (%)	UCL (%)	LCL (%)	UCL (%)
1.2-DICHLOROETHANE-D4	72.0	125.0	71.0	124.0
TOLUENE-D8	89.0	112.0	83.0	120.0
4-BROMOFLUOROBENZENE	80.0	124.0	81.0	124.0
Pentafluorobenzene	50.0	200.0	50.0	200.0
1,4-Difluorobenzene	50.0	200.0	50.0	200.0
Chlorobenzene-D5	50.0	200.0	50.0	200.0
1,4-Dichlorobenzene-D4	50.0	200.0	50.0	200.0

†: Results based on recovery data from 2020.

Figure 1. Example Total Ion Chromatogram for a Midpoint VOA Calibration Standard†



†: Data file Std060.D (60 μg/L). GC/MS acquisition parameters are given by Table 4.